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NUTRITION AND PHYLOGENY IN THE WATER MOLDS

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THE water molds are usually considered the most primitive of the true fungi and are generally found on plant and animal substrata in aquatic or semiaquatic environments. In the following review, an attempt has been made to gather together and evaluate the significant contributions to our knowledge of their nutrition and metabolism. By integrating the data into an ordered whole, it has been possible to consider the bearing of nutritional criteria on some aspects of the phylogenetic relationships of the water molds.

NUTRITION AND METABOLISM

The following is a brief résumé of the results of nutritional investigations of the water molds. The Chytridiales, which to date appear to be completely autotrophic for all essential vitamins (Ajello, 1948; Quantz, 1943; Stanier, 1942; Whiffen 1941) may be segregated into two groups. The first includes species which can use one or more of the three substances chitin, cellulose, or keratin as sources of carbon (Haskins, 1939; Karling, 1945, 1946, 1947; and others). The most extensive investigations, however, have been made with those chytrids capable of decomposing cellulose. The ability to utilize other carbohydrates is limited more or less to cellobiose and glucose, the constituent sugars of cellulose, although xylose, mannose, and others may support some growth. Although it has been found (Quantz, 1943; Whiffen, 1941) that some of these fungi prefer inorganic nitrogen such as nitrate- or ammonium-N, Stanier (1942), working with *Rhizophlyctis*, determined that nitrate alone would not furnish this essential element. *Polychytrium* (Ajello, 1948), which can decompose both chitin and keratin, can utilize no carbohydrates other than glucose and starch. Furthermore, although organic-N is preferred to inorganic, nitrate and ammonium salts do support some growth. The second category includes fungi (Whiffen, 1941) which are not capable of decomposing cellulose and which lack the ability to grow on inorganic-N alone.

The nutrition of the Blastocladiales, which appears to be highly specialized, has also been investigated by Cantino (1948, 1949), Emerson and Cantino (1948), Leonian and Lilly (1938) Quantz (1943), and Stuben (1939). Here it would be wise to consider one group containing *Allomyces* and *Blastocladiella*, and the other containing *Blastocladia*. Quantz found that both *Allomyces* and *Blastocladiella* lack the ability to synthesize thiamine. Leonian and Lilly reported that *Allomyces* does not grow on a mineral-dextrose medium containing ammonium nitrate, thiamine, and amino acids. This, however, did not demonstrate conclusively whether or not the fungus is heterotrophic or autotrophic for thiamine. Although Ronsdorf (1935) found that a "bios" solution promoted growth of *Allomyces*, no definite conclusions can be drawn since several vitamins were probably present. That biotin is probably not necessary for growth is clear from Quantz's work and unpublished results of the author on two strains of this fungus. Quantz indicated that various sugars, such as glucose, fructose, maltose, and others, yield an increase in growth over that obtained on a basal medium without these sugars. Wolf and Shoup (1943), however, in studying the effects of carbohydrates on the respiration of four species of *Allomyces*, came to the conclusion that only dextrin (and for a single species, sucrose and maltose also) is respired. Since it is unlikely that a fungus which respires dextrin cannot respire glucose, these results do not present a serious objection to Quantz's observations. Finally, it is probable that nitrate cannot be reduced by these organisms, and that nitrogen must be supplied in the form of amino acids or other organic nitrogen compounds (although ammonium-N may be metabolized by *Allomyces*; cf. Quantz). On the other hand, the studies by Cantino have shown that *Blastocladia* is heterotrophic for three essential vitamins, namely, nicotinamide, thiamine, and biotin. *Blastocladia* can use a greater variety of sugars for growth than can the other two genera. Nitrogen must be supplied in the form of amino acids, and methionine seems to be an essential source of sulfur. This may well represent an exception to current concepts that, so far as is known, no fungus has a natural absolute requirement for a specific amino acid. Indeed this should not be surprising in view of established requirements of this kind for the lactic acid bacteria.

As yet, nothing can be said about the nutritional requirements of the Monoblepharidales. The flagellation of the zoospores offers evidence that they are closely related to the Blastocladiales, but there are no physiological data which can be used to support or refute this point of view.

Following the early work of Pieters (1915), studies on the Saprolegniales were initiated by various investigators (Bhargava, 1943, 1945a, 1945b, 1945c, 1946; Leonian and Lilly, 1937, 1938, 1940; Moreau and Moreau, 1940; Saksena and Bhargava, 1941; Saksena and Bose, 1944; Volkonsky, 1932a, 1932b, 1933a, 1933b, 1934; Whiffen 1945). The Saprolegniales grow vigorously on various kinds of media, in which the carbon source may be glucose, maltose, dextrin, starch, or perhaps several other sugars, and some amino acids. Of various sugars tested, however, Whiffen found that *Dictyuchus* can grow vigorously only on glucose, and Volkonsky determined that *Aphanomyces* can utilize no sugars. Most of the Saprolegniales are probably completely autotrophic for vitamins. On the other hand, some may have partially or completely lost the ability to synthesize biotin (Bhargava, 1946; Leonian and Lilly, 1940, and references cited therein), and in one instance, possibly thiamine (Whiffen, 1938). With the exception of *Dictyuchus* (Whiffen, 1945) and *Brevilegnia* (Bhargava, 1945a, 1945b), members of this group are not able to grow on nitrate or sulfate as sole sources of nitrogen or sulfur, respectively. Whether or not ammonium-N can be used in all instances, however, has not been clearly ascertained (cf. Volkonsky, 1932a, 1932b, 1933a, 1933b, 1934; Leonian and Lilly, 1938; Saksena and Bhargava, 1941; as compared to Bhargava, 1945b; Whiffen, 1945). Nitrogen in the form of amino acids or other compounds, and sulfur, as cystine, methionine, gluthathione, or perhaps hydrogen sulfide or thiosulfate, were found to be generally used by those organisms investigated.

In a closely related group, the Leptomitales, we are limited to the work of Schade (1940) on *Leptomitus* and *Apodachyla*. Both fungi are completely autotrophic for essential vitamins. With regard to their carbon nutrition, however, generalizations cannot be made. *Leptomitus* is unable to assimilate sugars and must be supplied with other sources of carbon (e.g., amino or fatty acids), whereas *Apodachlya* grows vigorously either on sugars or amino acids. Furthermore, *Leptomitus* and *Apodachlya* differ from the Saprolegniales in two basic respects: (1) nitrogen must be supplied in organic combination, since neither nitrate nor ammonium compounds will support growth; (2) both organisms are capable of reducing sulfate to satisfy their sulfur requirements.

Finally, it is necessary to consider the aquatic members (Pythiaceae) of the Peronosporales. Little is known about their carbon nutrition, although the studies of Volkonsky (1934) and the author's work (1949) on *Pythiogeton* have shown that various sugars may serve as suitable sources of carbon. It has been demonstrated conclusively that most of the Pythiaceae are either partially or completely heterotrophic for thiamine, or one of its components, pyrimidine (Cantino, 1949; Fries, 1938; Kavanagh, 1942; Kögl and Fries, 1927; Leonian, 1924; Leonian and Lilly, 1938, 1940; Lilly, 1940; Lilly and Leonian, 1940; Payette and

Perrault, 1944; Robbins, 1938a, 1938b, 1942; Robbins and Kavanagh, 1938a, 1938b; Saksena, 1935, 1939, 1940, 1941). Although Ronsdorf (1935) reported that a "bios" solution had been found to produce growth in four species of *Phytophthora* and in one species of *Pythium*, it is clear that most if not all members of the Pythiaceae are not heterotrophic for biotin. Finally, investigations indicate that sulfate is reduced by several species of *Pythium* (Kincaid, 1929; Leonian and Lilly, 1940; Saksena, 1935, 1940; Volkonsky, 1934), and by *Pythiogeton* (Cantino, 1949), whereas nitrogen, which probably can not be assimilated as nitrate (however, see Hawker, 1939; Ronsdorf, 1935), is used in organic combination and in the form of ammonium compounds.

Although a knowledge of the metabolic processes of aquatic Phycomycetes would undoubtedly be of great help in further elucidating their general biology and phylogenetic relationships, this phase of their physiology is least understood. With the exception of the studies of Schade and Thimann (1940) on *Leptomitus*, of Emerson and Cantino (1948) and Cantino (1949) on *Blastocladia*, and of some rather preliminary respirometric data by Wolf and Shoup (1943) and Shoup and Wolf (1946) on *Allomyces*, our knowledge of the metabolism of the water molds is indeed nebulous. All that can be said from the point of view of comparative metabolism is that *Leptomitus* is a strict aerobe which (1) can oxidatively deaminate certain amino acids, (2) can oxidize various fatty acids to carbon dioxide and water but cannot respire sugars, and (3) carries on a very efficient oxidative assimilation. On the other hand, *Blastocladia*, which is not closely related to *Leptomitus*, (1) will grow actively under extremely low concentrations of oxygen, (2) can dissimilate a number of sugars, and (3) has a fermentative rather than an oxidative type of metabolism.

PHYLOGENY

Although a great deal of interest has centered on the phylogeny of the water molds (Atkinson, 1909; Bessey, 1942; Cavers, 1915; Cook, 1928; Mez, 1929; Petersen, 1909; Sparrow, 1935; Scherffel, 1925; Weston, 1936; and others), mycologists have been particularly handicapped by the lack of factual information necessary for a proper evaluation of evolutionary phenomena. As Sparrow (1943, p. 3) has indicated: "No investigator of these fungi pursues his studies for long before he comes to appreciate the enormous lacunae in our present knowledge of them." Furthermore, in the search for relationships, speculations have been based primarily on comparative morphology and on the mechanism of sexual and asexual reproduction. Any account of phylogenetic relationships of the aquatic Phycomycetes, however, should take into consideration all dynamic aspects of their life processes. The critical study of nutrition and metabolism which has led to the proper interpretation of those physicochemical processes which are characteristic of living entities may ultimately provide important correlative data for an integration of evolutionary phenomena.

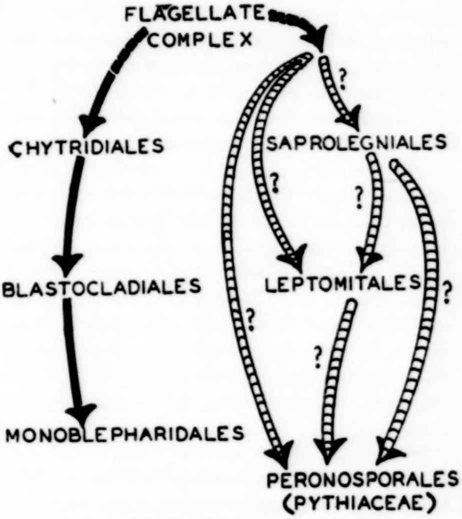

FIG. 1. PHYLOGENETIC RELATIONSHIPS AMONG THE WATER MOLDS, BASED UPON MORPHOLOGICAL AND LIFE-CYCLE CHARACTERISTICS

It has been postulated by Scherffel that aquatic Phycomycetes can be segregated into two main groups, each of which has evolved from different ancestors. He labeled these groups the uniflagellate "Chytridineen" and the biflagellate "Saprolegniineen-Peronosporineen." Sparrow (1943, p. 4) found himself in agreement with the main aspects of Scherffel's thesis ". . . since they seem best to fit the facts we know now."

The relationships that exist in the aquatic Phycomycetes, based upon life histories and morphological criteria, are summarized in Fig. 1. Two, or perhaps more, distinct series of water molds may have arisen independently from different ancestral groups, which in turn were probably derived from a primitive flagellate complex. The Blastocladiales are closely related to both the Chytridiales and the Monoblepharidales, and apparently bridge the "phylogenetic hiatus" between the two. It is somewhat more difficult, however, to render judgment on any definite point of view with regard to the Saprolegniales-Leptomitales-Peronosporales complex. The Leptomitales show clear and unmistakable affinities with both the Saprolegniales and the Peronosporales, and yet the Peronosporales have many fundamental characters in common with the Saprolegniales. The Peronosporales are primarily terrestrial fungi and only the Pythiaceae can be logically considered as water molds. For this reason, assuming that terrestrial forms were evolved from aquatic ancestors, the Pythiaceae (in the Peronosporales) could be considered as the terminal group of the series, if only one series does indeed exist. Little can be said concerning the relationships of the Lagenidales and Plasmodiophorales to the other orders of aquatic fungi, each of which appears to be composed of clearly related organisms. Until more extensive and precise information on life cycles, sexuality, and physiology is available, they cannot be considered seriously in a discussion of phylogenetic relationships in the water molds.

An approach to the problem of nutritional evolution in microorganisms was made by Lwoff (1932, 1936, 1938, 1944). Although Lwoff has dealt primarily with the protozoans, the general aspects of his thesis may apply to the water molds. In brief, Lwoff postulated a physiological evolution which led to degeneration and heterotrophism, such a progressive loss of capacity for synthesis rendering the organisms more and more dependent upon the environment. It is further assumed that specialization in nutritional requirements is indicative of a highly evolved group, whereas an organism autotrophic for all known vitamins, and which, let us say, can reduce simple inorganic sources of sulfur and nitrogen, would be considered relatively primitive.

It is, of course, possible to conceive of physiological evolution based on a thesis that is diametrically opposed to the one above. For example, the number of biochemical steps involved in the synthesis of proteinaceous materials from inorganic sources of nitrogen and sulfur would presumably exceed that necessary for the same synthesis from assimilable amino acids. Assuming that the greater degree of complexity of a biosynthetic reaction is characteristic of a more highly evolved condition, a microorganism which is capable of assimilating nitrate and sulfate could then be considered advanced, and not primitive (cf. for example van Niel's 1949 discussion on evolution of photosynthesis). If this were used as a basis for phylogenetic relationships among the water molds, however, some fungi which appear to be the most primitive in their morphological and life-cycle characteristics would seem to possess an advanced type of metabolism, and vice versa. For example, the Blastocladiales, usually assumed to have been derived from the Chytridiales, would be characterized by a primitive metabolic mechanism, whereas the chytrids would have to be considered as representing a more highly advanced level of development. Admittedly, from a speculative point of view, physiological evolution may have involved either a progressive loss in synthetic capacities with its associated decrease in complexity of the metabolic mechanism, or a progressive increase in synthetic capacities and a similar increase in complexity of the metabolic mechanism, or both. A consideration of our knowledge of higher plants and animals would seem to indicate that in the main evolution has progressed toward specialization, but with an associated increase in anatomical and morphological complexity. However, as van Niel (1949) has indicated, "it will be necessary to accept the occurrence of a physiological evolution characterized by a loss of synthetic ability, and it is even probable that this is the chief if not the exclusive route by which the vast majority of now living organisms have originated." For the present discussion, it will be assumed that synthetic capacities have evolved, in the sense of Lwoff, toward specialization, with an associated decrease in complexity of biosynthetic reactions.

Such an approach in conjunction with life-cycle and morphological data may help to establish further criteria with which to evaluate phylogenetic relationships in the water molds. Because of the relative lack of physiological criteria for interpreting fundamental relationships, the basic skeleton of any phylogenetic scheme in the water molds must of necessity (for the present) be based solely on morphological and life history data. The author's approach is on this basis. Physiological criteria, then, must be applied from a supplementary point of view. As such, they may provide further standards for judging relationships which are already well-founded on morphological grounds. Furthermore, in instances where morphological evidence is insufficient, it may be possible to use nutritional and metabolic data to shift the emphasis in one direction or another. Thus a more satisfactory explanation of phylogeny might be achieved. Finally, it is of interest to consider nutrition and metabolism per se as a separate entity. Although the biological activities of any organism are the result of many interrelated factors, the progressive losses in synthetic abilities and the fundamental changes which may have occurred in their metabolic processes are in themselves worthy of investigation. It may logically be objected that the production of many single-

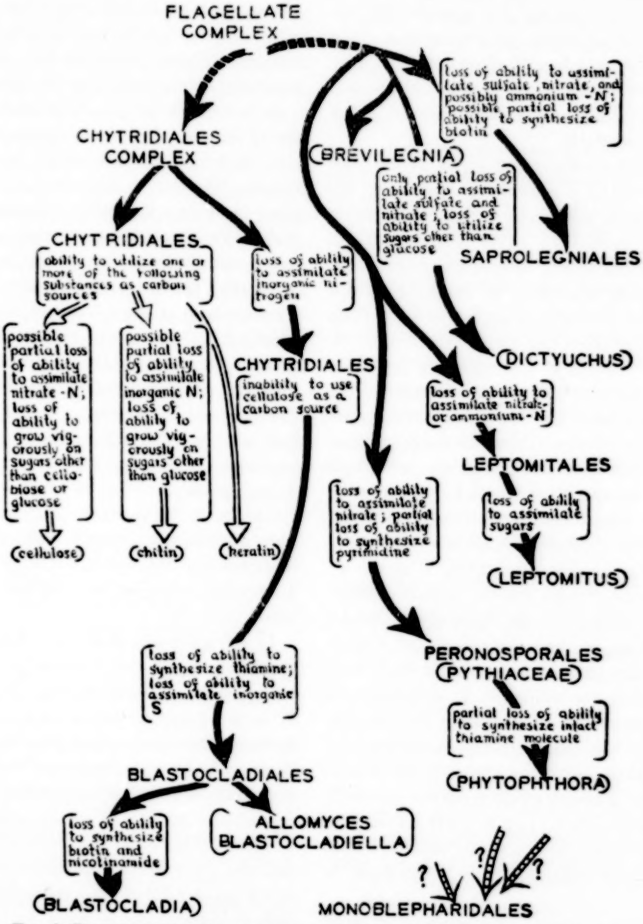
FLAGELLATE COMPLEX
CHYTRIDIALES COMPLEX
CHYTRIDIALES
ability to utilize one or more of the following substances as carbon sources
possible partial loss of ability to assimilate nitrate-N; loss of ability to grow vigorously on sugars other than cellobiose or glucose
(cellulose)
possible partial loss of ability to assimilate inorganic N; loss of ability to grow vigorously on sugars other than glucose
(chitin)
(keratin)
loss of ability to assimilate inorganic nitrogen
CHYTRIDIALES
inability to use cellulose as a carbon source
loss of ability to synthesize thiamine; loss of ability to assimilate inorganic S
BLASTOCLADIALES
loss of ability to synthesize biotin and nicotinamide
(BLASTOCLADIA)
ALLOMYCES BLASTOCLADIELLA
loss of ability to assimilate sulfate, nitrate, and possibly ammonium-N; possible partial loss of ability to synthesize biotin
(BREVILEGNIA)
only partial loss of ability to assimilate sulfate and nitrate; loss of ability to utilize sugars other than glucose
SAPROLEGNIALES
(DICTYUCHUS)
loss of ability to assimilate nitrate- or ammonium-N
LEPTOMITALES
loss of ability to assimilate sugars
(LEPTOMITUS)
loss of ability to assimilate nitrate; partial loss of ability to synthesize pyrimidine
PERONOSPORALES (PYTHIACEAE)
partial loss of ability to synthesize intact thiamine molecule
(PHYTOPHTHORA)
?
?
?
MONOBLEPHARIDALES

FIG. 2. PHYLOGENETIC RELATIONSHIPS AMONG THE WATER MOLDS, BASED UPON NUTRITIONAL CHARACTERISTICS.

The term "loss of ability" is restricted in meaning. Most investigations of nitrogen nutrition in the fungi have attempted to show that a given organism can or cannot use, let us say, nitrate as the sole source of this element. However, in those instances where amino acids are required for growth, it has seldom if ever been shown by analysis whether or not nitrate- or ammonium-N is actually assimilated simultaneously. Therefore, for example, "loss of ability to assimilate nitrate" implies that this substance, *when used as the sole source of nitrogen*, will not support growth.

gene biochemical mutants in *Neurospora* without associated morphological changes should presuppose caution in emphasizing nutritional criteria in evolutionary phenomena. If such results are ultimately obtained among the aquatic Phycomycetes, where biochemical genetic studies have not been made, physiological characteristics may still prove to be significant in a relatively homogeneous morphological framework where other criteria are not available.

The relationships among the water molds may now be considered on a nutritional basis (Fig. 2). In the uniflagellate series, any definite conclusion is necessarily premature. The Blastocladiales, which have lost the ability to synthesize thiamine, cannot decompose cellulose, and cannot grow on inorganic sources of nitrogen, appear to have been derived from the chytrids, whose nutritional requirements are somewhat less exacting. The fact remains, however, that only a small fraction of the chytridialian complex has been studied in pure culture; whether or not a narrow range of synthetic abilities characterizes the group as a whole is not known. In the Blastocladiales, a representative of each genus has been investigated, and the results of the studies of vitamin and nitrogen nutrition are generally consistent. Finally, although nutritional criteria may be useful in reflecting on the derivation of the Monoblepharidales nothing is known of their nutrition and metabolism, and further consideration must wait until physiological data are available. In conclusion, it is impossible to decide if evolution in the uniflagellate series has been entirely developmental and morphological, occurring within a nutritional framework encompassing either a narrow or a wide range of synthetic ability; or if synthetic capacities have evolved in a unidirectional manner within the heterogeneous morphological framework of this group.

Assuming that zoospore flagellation is a character of fundamental import in phylogenetic considerations, the biflagellate series has evolved along an independent path from that of the uniflagellate complex. Using this as a basic hypothesis, we come to a consideration of their losses in synthetic capacities, based upon the results of a relatively large number of investigations. Only two organisms, *Dictyuchus* and *Brevilegnia*, which are obviously saprolegniaceous fungi in their morphological and sexual characteristics, seem to differ appreciably from the other members of the order. They are less specialized than most of the Saprolegniales in their ability to utilize sulfate and nitrate, whereas the group as a whole has lost the ability to grow on such sources of sulfur and nitrogen. It is possible that some members of the order may no longer be able to synthesize biotin, but the evidence indicates that most of them are completely autotrophic for vitamins.

Although the Leptomitales have completely lost the ability to grow on inorganic sources of nitrogen, they have retained their capacity to reduce sulfate. The latter characteristic would tend to place them in a distinctly different category from that of the Saprolegniales; they seem, indeed, to have evolved along a completely independent path.

Finally, the aquatic members of the Peronosporales have certain characteristics in common which set them apart from the two foregoing groups. Almost all of the Pythiaceae have suffered a partial or complete loss of ability to synthesize thiamine, and in some cases only the pyrimidine half of the molecule is produced. They differ basically, therefore, from the Leptomitales and Saprolegniales, neither of which requires thiamine. Evidence indicates that whereas the Pythiaceae have not lost the ability to reduce sulfate and thus resemble the Leptomitales, they are able to use ammonium-nitrogen but cannot grow on nitrate alone.

Is it significant that nutritional requirements, at this stage in our knowledge, are rather consistently different among these three major orders? It is not implied that a sharp dichotomy exists between those organisms requiring organic N and those which can use inorganic N such as ammonium compounds, since the loss of ability to synthesize one of any number of amino acids would result in a dependency upon a supply of organic N. The number of essential S-containing compounds is much more limited, and the ability or inability to reduce sulfate would seem to be of greater significance. It is supposed, then, that progressive losses in the synthetic capacities of the Saprolegniales-Leptomitales-Peronosporales complex have evolved along two independent paths, one having given rise to the Saprolegniales, and the other to the Peronosporales and Leptomitales. From a strictly nutritional point of view, the Leptomitales are therefore more closely related to the Peronosporales than to the Saprolegniales.

The foregoing discussion when considered in toto points clearly to the fact that no one set of criteria can be considered exclusive of all others in appraising phylogenetic relationships. For example, if nutritional criteria alone were to be employed in such evaluations, it would be possible to hypothesize that the Peronosporales gave rise to the Blastocladiales. This would have involved a loss of capacity to reduce sulfate, with further losses in the synthetic abilities of *Blastocladia* to produce other essential vitamins. On the basis of morphological evidence and the details of life histories in these two groups, such an hypothesis would be absurd. In the Saprolegniales-Peronosporales-Leptomitales complex, however, where the relationships within the group are not yet reasonably clear, it is possible to show how nutritional characteristics may have been evolved. It is evident that nutritional criteria need not have evolved during the same time interval, indeed not even along the same paths, as those other criteria based on morphology and life histories. It is not necessarily implied that because the nutritional characteristics of the Leptomitales and Peronosporales seem to have evolved along different lines from the Saprolegniales, the evolution of morphological criteria should follow this same pattern. Future investigations of the biology of the water molds will undoubtedly help the mycologist to determine whether or not the nutritional evolution of the group can be reconciled with existing morphological relationships.

SUMMARY

A survey of the literature indicates that there exist inter-ordinal differences in the nutritional requirements of the aquatic Phycomycetes.

1. In the uniflagellate series, those Blastocladiales which have been investigated appear to be more highly evolved, in the sense of Lwoff, than the Chytridiales; but the evidence is insufficient to warrant any far-reaching generalization.

2. In the biflagellate series, the Leptomitales and the aquatic members of the Peronosporales are more closely related to one another in their synthetic capacities than either is to the Saprolegniales.

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CYTOCHEMICAL REACTIONS OF NUCLEIC ACIDS

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IN current biological and biochemical research a great deal of attention is being directed toward the nucleic acids and nucleoproteins and the role, or roles, which they play in life processes. Through the efforts of the cytochemist the nucleic acids may be identified, localized, and quantified within individual cells. Such cytochemical observations afford an important link between the chemistry of tissue extracts and the physiology of the living cell. As Danielli has emphasized (1946, 1947), the validity of the observations, and consequently of the hypotheses drawn from them, depends on the reliability of the methods by which the material is prepared. Although some of the older papers dealing with the cytochemical techniques have been summarized in the reviews by Gersh (1941) and Dempsey and Wislocki (1946), there has been no comprehensive review of the more recent literature. The purpose of this paper is to review the most pertinent literature concerning the cytochemical techniques for studying the nucleic acids and to discuss their validity as specific tests.

When the cytochemist attempts to interpret the results of qualitative or quantitative tests run on tissue sections, he is confronted with many unique and baffling problems. Chemical reactions within the cell are seldom, if ever, subject to the controlled conditions of test-tube chemistry, but take place within the peculiar chemical and physical conditions found in protoplasm. Furthermore, most of the present cytochemical reactions are run on dead cells. Since very little is known of the effect of death by various causes on the physical and chemical condition of protoplasm, any attempt to extrapolate from the dead to the living state is fraught with danger. Thus, the very nature of the material imposes on the cytochemist limitations which must be kept in mind in evaluating the techniques and in interpreting the results.

More specifically, in considering the validity of any cytochemical technique, special consideration should be given to the following points: (1) the specificity of the chemical reaction between the substance to be identified and the test reagents, (2) the accuracy and the ease with which the reaction product may be detected within the cell, (3) the degree to which the protoplasmic constituents are retained with a minimum distortion from the living conditions, (4) the extent to which the protoplasmic constituents or the reaction products are diffusible, (5) the degree to which the reacting groups come into contact with each other and are free to react, that is, are not bound in such a way that the expected reaction cannot occur. If quantitative determinations are desired, consideration must be given to such additional factors as: (6) the number of reacting groups which may be involved in the dye binding or the color reaction, (7) the orientation and aggregation of the reacting protoplasmic material or the reaction products, (8) the exact thickness of the cytological preparation, and (9) the sensitivity and accuracy of the means of determining the amount of light absorbed by the specific compounds being analyzed.

SPECIFICITY OF THE REACTION

1. Chemistry of the Nucleic Acids

Information concerning the chemical properties of the nucleic acids is essential for any discussion of the specificity of the cytochemical tests. For this, the cytochemist is dependent on the results of chemical investigations. Since the chemistry of the nucleic acids has recently been thoroughly reviewed (Chargaff and Vischer, 1948; Gulland, Barker, and Jordan, 1945; Loring, 1944) and its various aspects have been extensively discussed in the three symposia held in 1947 (Cold Spring Harbor Symposia on Quantitative Biology, *12*; Symposia of the Society for Experimental Biology, *1*; Symposium on the Chemistry and Metabolism of Nucleic Acids and their Constituents, Federation Proceedings, *6*), a detailed review of the literature will not be given here. Only those facts and concepts which are of special significance to the cytochemist will be discussed.

A comparison of the information and viewpoints expressed in the older reviews (Levene and Bass, 1931; Allen, 1941; Mirsky, 1943; Greenstein, 1944) with those of the more recent papers shows that the concepts concerning the chemistry of the nucleic acids have changed greatly within the last few years. The present state of knowledge of the nucleic acids has been compared with that of the proteins at the beginning of this century (Chargaff and Vischer, 1948). Not only is there a relatively small amount of well established information, but also many of the data which were obtained by the earlier investigators are now regarded with suspicion because of serious faults in the techniques they used. This state of affairs has led to considerable confusion in the biochemical literature, and the confusion has often been reflected in the cytochemical papers.

That the nucleic acids can be grouped into two main types on the basis of easily detectable chemical differences has been known since the early days of nucleic acid chemistry. Various terms, such as thymonucleic or desoxyribonucleic acid, and yeast or ribonucleic acid, have been used to distinguish the two types. Since a complete characterization of the hydrolytic products has been carried out for nucleic acids from only a few types of material, more accurate terms for the designation of those nucleic acids in which the sugars have not been identified are desoxypentose nucleic acid and pentose nucleic acid. Substances identified in the hydrolytic products from such typical desoxypentose nucleic acids as fish sperm and beef thymus extracts are: 2-desoxy-D-ribose, two pyrimidines (thymine and cytosine), two purines (adenine and guanine), and phosphoric acid. Substances identified in pentose nucleic acid hydrolysates of such thoroughly studied materials as yeast, pancreas, liver, and tobacco mosaic virus, are: D-ribose, two pyrimidines (uracil and cytosine), two purines (adenine and guanine), and phosphoric acid (Levene and Bass, 1931; Gulland, Barker, and Jordan, 1945; Chargaff and Vischer, 1948). These results suggest that the component substances in the two types of nucleic acid are the same except for the presence or absence of an hydroxyl group on carbon 2 of the pentose sugar and of a methyl group on carbon 5 of one of the pyrimidine bases.

The fact that these products are consistently obtained from nucleic acids gave rise to an assumption, formerly widely accepted, that there are only two kinds of nucleic acids and that they have a relatively constant composition. In a recent critical review of the older analytical work, Gulland (1947a) pointed out that the yield of known substances in hydrolyzed nucleic acids is far from quantitative and that little serious effort to identify other substances seems to have been made. Many of the most widely used biochemical tests detect only groups within the molecule, such as pentose sugars, desoxycarbohydrates, or some of the purine or pyrimidine groupings. The careful, complete identification of the hydrolytic compounds is often neglected. Furthermore, the drastic chemical procedures usually used in extracting, purifying, and hydrolyzing the nucleic acids may very well destroy certain groups, fail to liberate others, lead to interconversion of compounds, or in other ways produce artifacts. In view of these factors, a number of the most competent of modern biochemists (Gulland, Barker, and Jordan, 1945; Gulland, 1947a, b; Loring, Ordway, Roll, and Pierce, 1947; Vischer and Chargaff, 1948) have felt that in most instances the data are not sufficiently precise to permit definite conclusions concerning the composition of nucleic acids. If the nucleic acids cannot be regarded as having a constant composition, it follows that conclusions from cytochemical tests can be drawn only for the specific group which the procedure detects.

In considering the nucleic acids of the cell, of course, neither the biochemist nor the cytochemist is dealing with the separate components but rather with a complex nucleic acid molecule or macromolecule. Thus, the way in which the components are combined in the protoplasmic complex becomes of great importance. It has long been known that hydrolysis of isolated and purified nucleic acids yields nucleotides, each of which consists of a sugar, a nitrogen base, and phosphoric acid. Alkaline hydrolysis of a purified nucleotide preparation, or of the intact nucleic acid molecule itself, will split off phosphoric acid, leaving a base-sugar complex termed a nucleoside. On the other hand, the nitrogen bases may be removed by acid hydrolysis, leaving phosphoric esters of the sugar. The ease with which the bases are split off varies with the different types; the purines are liberated by a relatively mild acid hydrolysis, while the pyrimidines are split only by much more drastic treatment (Osborne and Heyl, 1908; Vischer and Chargaff, 1948). Many of the details concerning the nature of the linkages between the components of the individual nucleotides have been determined (Gulland, 1947b; Lythgoe and Todd, 1947). It is generally accepted that sugar-phosphate ester linkages bind the mononucleotides together, but the exact structure of none of the polynucleotides is completely known (Gulland, 1947b; Chargaff and Vischer, 1948).

The early investigators found the quantitative yields of the hydrolytic products of nucleic acids to be in keeping with the hypothesis that four mononucleotides, each containing one of the four different bases, are united in a fixed pattern to form a basic tetranucleotide out of which larger molecules are formed. Recent investigations, however, have indicated that neither the concept of a structural tetranucleotide with regularly arranged components nor that of a statistical tetranucleotide with the components present in equimolecular proportions is in harmony with all of the known data (Gulland, 1947a, b; Gulland, Barker, and Jordan, 1945; Loring, Ordway, Roll, and Pierce, 1947; Vischer and Chargaff, 1948). Thus, it is possible that nucleic acids present in different organisms, in different types of cells, or in the same cell at different physiological or developmental stages, may differ both in the number and kinds of nucleotides present and in their arrangement within the polynucleotide structure.

Since both types of nucleic acids may be obtained from tissue extracts in the form of large, highly asymmetric particles (Greenstein, 1944; Fletcher, Gulland, Jordan, and Dibben, 1944), it has usually been concluded that the nucleotides are present in the cell in a highly polymerized condition. The desoxypentose nucleic acids, in general, appear to be more highly polymerized than the pentoses. However, the data showing that particle size may vary with the extraction procedures and the subsequent treatment of the solution (Gulland, Barker, and Jordan, 1945) suggest that processes of polymerization or depolymerization may take place during the chemical procedures. In view of evidence of this nature, caution should be used in extrapolating from the physical properties found in solutions of isolated nucleic acids to the condition in living protoplasm.

These large complex polynucleotides, still imperfectly understood chemically, are the substances which the cytochemist attempts to detect and to localize within the cell. Up to the present time only a few techniques for doing this have been developed, all of which are based on reactions with only one of the components or with a specific group within the molecule. The Feulgen reaction is used to detect the presence of a desoxypentose. Basic stains supposedly react with the acidic groups of both pentose and desoxypentose nucleic acids. The specificity of the stain reaction is often tested by combining staining procedures with a treatment of adjacent sections with agents that remove the nucleic acids, i.e., ribonuclease, desoxyribonuclease, and acid hydrolysis. Special apparatus, constructed to measure the ultraviolet absorption in cytological preparations, may detect the characteristic absorption of the purine and pyrimidine skeletons of the nucleic acid molecule. A positive reaction with any one of these tests may be indicative of the presence of nucleic acid within the cell.

2. *The Feulgen Reaction*

One of the most widely used cytochemical reactions is the test, first worked out by Feulgen and Rossenbeck (1924), for the sugar obtained by hydrolysis of desoxypentose nucleic acid. Many modifications of the original technique have been made, but the ones most often employed are the procedures of de Tomasi (1936) and Stowell (1945). Essentially, the reaction consists of two parts: a short hydrolysis with normal hydrochloric acid heated to 60° C., followed by reaction of the hydrolyzed sugar with leucofuchsin to produce a magenta-colored compound. Neither unhydrolyzed desoxyribonucleic acid nor ribonucleic acid give this reaction. Since the Schiff's fuchsin-sulfurous acid reagent used in the Feulgen test has long been used as a qualitative test for aldehyde groups, the assumption is made that the effect of hydrolysis is to liberate free aldehyde groups in the desoxyribose molecule. The purplish-red compound formed by the Schiff reaction is generally thought to be a complex formed by the union of the free aldehyde with the decolorized pararosaniline (Rumpt, 1935; Schriner and Fuson, 1944).

The chief discussions concerning the validity of the technique as a specific cytochemical test have arisen from the difficulty of determining the exact effect of hydrolysis on the desoxyribonucleic acid in a tissue. Within the last year several reports of chemical and cytochemical studies on the effect of Feulgen hydrolysis have been made (Di Stefano, 1948a, b; Overent and Stacey, 1949; Li and Stacey, 1949; Ely and Ross, 1949a).

There is general agreement that one of the first, if not the first, effect of hydrolysis in normal hydrochloric acid at 60° C. is a liberation of purines. Li and Stacey (1949) have succeeded in isolating purines in the crystalline form and as picrates from hydrolysates of desoxyribonucleic acid. Most investigators, however, have not actually isolated the purines but have used characteristic ultraviolet absorption at 2600 Å as indicative of their presence. The reason for thinking that the absorbing substances are largely purine rests on chemical evidence that very drastic procedures, such as autoclaving at 175° C. for several hours (Vischer and Chargaff, 1948), are required to remove pyrimidines from desoxyribonucleic acid.

As a result of their experiments, Stacey and his coworkers (Li and Stacey, 1949; Overent and Stacey, 1949) concluded that the splitting of the glycosidic purine-desoxyribose linkages permits the shifting of a significant portion of the sugar from the furanose to the aldehydo configuration, thus freeing aldehyde groups for reaction with the Feulgen reagent. Since the colored complex formed after a short hydrolysis is insoluble, they concluded that the sugars are still bound in the polynucleotide chain by their phosphate linkages. Li and Stacey also presented evidence that procedures which result in a change in the physical state of the macromolecule, such as depolymerization, also liberate aldehyde groups.

It has been suggested by Li and Stacey (1949) and Di Stefano (1948a, b) that during the period of time required for the attainment of a maximum intensity of stain there is a progressive splitting of purines and freeing of aldehyde groups and that few, if any, additional changes occur. A point of maximum intensity of the Feulgen reaction was found to be reached after 12 minutes of hydrolysis by Di Stefano (1948b), and after 20 to 30 minutes by Ely and Ross (1949a). Both Bauer (1932) and Hillary (1939) found that the time required to reach a maximum intensity varies with the fixatives used in preparing the tissues; if solutions containing chromic acid are used the time varies from 5 to 30 minutes, while tissues fixed in solutions not containing chromic acid require only 4 to 8 minutes. The exact time for the attainment of maximum intensity of reaction is thus seen to vary under different experimental conditions. The above investigators also found that there is a progressive diminution in the intensity of the reaction if the time of hydrolysis is continued beyond the time of maximum reaction. Bauer (1932) and Hillary (1939) found that the stain is retained without obvious loss of color much longer if chromic acid is present in the fixatives than if it is missing.

Evidence from cytochemical studies of substances remaining in tissue sections and from chemical studies of products released into the hydrolysates from tissues indicates that continued hydrolysis results in degradation of the nucleic acid molecule. Stedman and Stedman (1943a; 1947), Danielli (1947); Li and Stacey (1949), and Ely and Ross (1949a) have demonstrated that the supernatant fluid from hydrolysis of purified desoxyribonucleic acid contains water-soluble, Feulgen-positive substances. Ely and Ross also made nitrogen and phosphorus determinations and ultraviolet studies of the substances found in the dialysates of hydrolyzed fixed, macerated thymus tissue. After 30 minutes of hydrolysis, they found nitrogen-containing compounds which absorbed in the ultraviolet, but no phosphorus. After hydrolysis of 5 hours, both nitrogen and organic phosphorus compounds were found in the dialysate. Overent and Stacey (1949) found that by increasing the acidity of the hydrolytic mixture up to pH 3.6 a great variety of soluble and insoluble fractions, including guanine, adenine, and desoxyribose phosphates, as well as other fragments difficult to characterize precisely, are formed. In view of these results, it must be concluded that acid hydrolysis of desoxyribonucleic acid may lead to the formation of small, diffusible degradation products.

It has also been demonstrated that prolonged hydrolysis of tissue sections results in the loss of all the detectable groups of the nucleic acid molecule. Di Stefano (1948b) and Ely and Ross (1949a) alike found that during prolonged hydrolysis in normal hydrochloric acid at 60° C. there is a progressive loss of material absorbing ultraviolet at 2600 Å, of Feulgen-reactive material, and of substances possessing affinity for basic stains. Ely and Ross also demonstrated by microincineration studies that after 30 minutes of hydrolysis very little inorganic ash is left in tissue sections. The rapidity with which the Feulgen-positive material is removed from the nuclei has been shown to vary with the fixative used in the preparation of the tissue (Bauer, 1932; Hillary, 1939; Di Stefano, 1948).

The demonstration of the formation from desoxyribonucleic acid of hydrolytic products which produce colored, water-soluble complexes on reacting with the Schiff's reagent led Stedman and

Stedman and other investigators of the Edinburgh laboratories (Stedman and Stedman, 1943a, b, 1944, 1947; Choudhuri, 1943; Carr, 1945) to criticize the validity of the Feulgen technique for locating desoxyribonucleic acid. They have maintained that the nucleic acid is located largely, though not necessarily exclusively, outside the chromatin and that the water-soluble dye formed as a result of the Feulgen reaction is adsorbed by a specific protein, chromosomin, in the chromosome. Histochemical evidence that the desoxyribonucleic acid is localized within the chromatin material and thus that the Stedmans' claims cannot be correct has been presented by Callan (1943), Barber and Callan (1944), Caspersson (1944), Stowell (1945, 1946a), Dodson (1946), and Brachet (1946, 1947). Stacey and his coworkers and Di Stefano have felt that their chemical evidence also refutes the Stedmans' idea that the colored structures are the result of non-specific staining by soluble dye complexes. They have pointed to their evidence that in the early hydrolytic phases of the Feulgen reaction the chief change is the splitting of the purine-sugar linkages and that after this the sugars are still bound in the polynucleotide chain. Ely and Ross, on the other hand, thought it had not been clearly determined whether the depolymerization of the nucleic acid precedes or follows the splitting off of purines, and hence that the Stedmans' contention could neither be affirmed nor denied.

One additional point in evaluating the specificity of the Feulgen technique should be discussed. It must be ascertained that under the conditions of the test the desoxyribonucleic acid is the *only* substance that will react with the Feulgen reagent. Since most free aldehydes, and certain other groups, may oxidize leucofuchsin, it is to be expected that a number of protoplasmic substances will produce a colored compound by reacting with the Schiff's reagent. The appearance of color has been reported following the addition of decolorized fuchsin to myelin sheaths of nerves, adipose tissue, secretory granules of fresh pancreas and adrenal gland (Liang, 1947), glycogen, starch, and lignins (Bauer, 1933; Hillary, 1939). It is possible, however, to distinguish these substances from desoxyribonucleic acid because all of them give the reaction without the previous hydrolysis which is necessary for the nucleic acid test. In certain tissues, particularly after fixation with mercuric chloride, a cytoplasmic reaction occurs with the Feulgen reagent even after hydrolysis. It has been suggested that a lipoprotein substance, sometimes termed "plasmalogen," (Hillary, 1939; Stowell, 1945) is responsible for this reaction. The distinction between tissue aldehydes and the groups released by hydrolysis of desoxyribonucleic acid may be made by a technique devised by Danielli (1949) in which the tissue aldehydes are rendered inactive by treatment with hydroxylamine prior to hydrolysis.

In summary, it may be concluded that the Feulgen reaction results in the formation of a colored substance by the reaction of the aldehyde groups freed by acid hydrolysis of the desoxypentose nucleic acid with reduced fuchsin. In the opinion of the majority of investigators, this reaction takes place in situ, provided a time of hydrolysis only sufficient to produce a maximum coloration is used. However, in view of the criticisms that have been raised, conclusions concerning the precise localization of the nucleic acid should be accepted with some reservation, and if possible checked by comparison with other cytochemical tests. As a quantitative technique the Feulgen reaction is subject to even greater criticism. As Ely and Ross (1949) have pointed out, quantitative measurements would have little value if the hydrolytic procedures remove some of the depolymerized fragments. Furthermore, neither the number of purine-sugar linkages that exist in polynucleotides of different types, nor the number of aldehyde groups freed by the hydrolytic procedures have been precisely determined. Thus, it is difficult to determine the relationship between the dye-binding groups and the amount of purine nucleotides. At best, such calculations would completely ignore the pyrimidine components of the nucleic acid.

3. *Basic Staining*

It has long been known that nuclei and certain cytoplasmic components possess a strong affinity for basic stains. Procedures for using the basic stains have not been standardized, and great variation in the strength of stain, staining and destaining procedures, and the use of fixatives prior to staining is to be found in the literature. A complete, concise compilation of the different techniques used has recently been published in tabular form by Lillie (1949).

The fact that structurally different dyes, resembling each other chiefly in the possession of basic radicals, give good staining reactions with cell parts containing nucleic acid supplies circumstantial evidence that the process of staining involves an acid-base reaction. Michaelis' study of the reaction between purified solutions of yeast nucleic acid and some of the basic dyes (toluidine blue, thionin, methylene blue, and pyronin) showed that a salt-like union between the dye and the nucleic acid molecule occurs. Kurnick and Mirsky (1950) have studied the stoichiometry of the reaction between methyl green and the desoxyribonucleic acids found in fixed nuclei and obtained from purified extracts. They found that if the temperature and pH are controlled, there is a constant ratio of one dye molecule to ten phosphorus atoms in the dye-nucleic acid complex. They also found that histone and lanthanum compete with the basic dye in the reaction with desoxyribonucleic acid and have interpreted this as indicating that all three basic compounds have a common site, presumably the phosphoric acid groups, of attachment to the nucleic acid molecule.

Evidence is available, however, that indicates that the reaction between basic dyes and nucleic acids is not merely a simple ionic union. Kurnick (1950a) found that while all triphenylmethane dyes with *two* amino groups react specifically with highly polymerized nucleic acid, those triphenylmethane dyes with *three* amino groups are not specific. He proposed an hypothesis involving stereochemical factors to explain the difference in behavior of these closely related dyes. Many workers (Lison, 1935a, b; Kelly and Miller, 1935a, b; Michaelis and Granick, 1945; Michaelis, 1944) have shown that the color of metachromatic basic dyes depends on the nature of the acid in the dye-acid complex, thus indicating that different kinds of chemical unions change the optical properties of the dye.

Michaelis (1947) reported that, if the specific dyes are allowed to react with the nucleic acids in tissue sections, a strong ionic bond will hold the dye to the nucleic acid, while the excess dye which is adsorbed or loosely bound within the cell is removed by washing with water or alcohol.

On the basis of Michaelis' opinion that prolonged washing in alcohol (in the absence of any precise statement, it may be assumed that he referred to 95 per cent ethyl alcohol) will remove non-ionically bound stain, Di Stefano (1948b) concluded that the methyl green left in sections after overnight destaining in isopropyl alcohol is bound to the nucleic acid. For the same reason Pollister and Leuchtenberger (1949b) destained sections stained in methyl green overnight in 95 per cent alcohol. However, when methyl green was combined with pyronin in the Unna-Pappenheim stain, destaining was carried out in tertiary butyl alcohol. The rapidity with which sections that have been stained with methyl green, methyl green-pyronin, and toluidine blue will destain has been found to vary with the kind of alcohol used (Lumb, unpublished data).

Special consideration should be given to a mixture of two basic dyes which has been used a great deal, especially by Brachet (1940, 1944), for the differential staining of both nucleic acids in the same preparation. This is Unna's modification of the Pappenheim mixture of methyl green and pyronin. According to Brachet, under the conditions of the staining procedure there is a competition between the ribo- and desoxyribo-nucleic acids, so that the methyl green unites with the desoxyribo- and the pyronin with the ribo-nucleic acid. Kurnick, in the discussion following Michaelis' paper (1947) and in a later paper (1950a) presented the results of studies of the reactions of pyronin and methyl green on the two types of nucleic acids and nucleoproteins in different polymerization states. As a result of his experiments, Kurnick concluded that methyl green adheres more firmly to the higher polymers of either ribose or desoxyribose nucleic acid, while pyronin reacts more strongly with the lower polymers. He suggested that, since desoxyribonucleic acid is believed to be present in the cells in a more highly polymerized state than ribonucleic acid, the reaction of Unna's mixture reflects the relative states of polymerization rather than any specific chemical difference in the molecules. Another interesting phenomenon which accompanies methyl green staining has been observed by Pollister and Leuchtenberger (1949b), who found that after treating sections with hot water the chromatin no longer stains with methyl green, although a positive Feulgen test and ultraviolet studies indicated that desoxyribonucleic acid is still present. Gross analysis of liver tissue before and after hot water treatment showed no reduction in the amount of phosphoric acid. Pollister and Leuchtenberger concluded that the loss of stainability of the chromatin is due to a change in the physical state, presumably depolymerization, of the nucleic acid. Kurnick (1950a, b) also found that exposure of tissues to heat, 60°C for ten minutes, results in the loss of nuclear affinity for methyl green, presumably due to the depolymerization of the desoxyribonucleic acid.

If the nature of the reaction of the nucleic acids with the basic dyes is primarily an acid-base attraction, there is no reason to suppose that other strongly acidic protoplasmic components will not also stain. The mucoproteins, found principally in mucin, chondrin, and the basophilic granules of mast cells (Hempelmann, 1940; Holmgren and Wilander, 1937; Holmgren, 1940; Asplund, Borell, and Holmgren, 1940) are highly acidic because of the sulfuric acid radical on the hexosamine carbohydrate. The reaction of many of the basic dyes, such as toluidine blue, thionin, or polychrome methylene blue, toward acidic substances is metachromatic; the sulfuric acid esters of the mucoproteins stain a violet to red color, while the phosphoric acid esters of the nucleoproteins give a blue color. Thus, in some instances at least, the muco- and nucleo-proteins may be distinguished by the shade of basophilia. Holtfreter (1946) found that fatty acids, rancid fats, and phosphatides react with toluidine blue and methylene blue to give a blue violet color. Since fat solvents are customarily used in dehydrating and embedding, the possibility of fats or fatty acids remaining in cytological preparations is slight.

4. Basic Staining Combined with Enzymatic or Hydrolytic Removal of the Nucleic Acids

Although some investigators, such as Pollister and Leuchtenberger (1949a, b), Di Stefano (1948a, b), and Kurnick (1950b), have felt that under their staining conditions the basic dye reacts specifically with the nucleic acid, the general consensus seems to be that too great a reliance should not be placed on staining alone. Fortunately, a complementary procedure has been devised which, when used with basic staining, permits greater assurance in the detection of nucleic acids. In this technique, first used by Brachet (1940), adjacent sections of a tissue are given identical treatment except for the incubation of one of them with a specific nuclease. After the two slides are stained, inferences as to the location of the nucleic acids are drawn from the absence of basophilia in the digested section. The validity of this technique, of course, depends on the specificity of the action of the enzyme.

The nuclease most extensively used in histochemical tests is the one, first obtained from the pancreas by Jones (1920), which brings about the breakdown of large pentose nucleic acid molecules without the release of either phosphoric acid or nitrogen bases. This enzyme, variously termed ribonuclease, ribonucleinase, ribonucleotidase, ribonucleodepolymerase, has been shown to act specifically on ribonucleic acid to form small, diffusible units. The isolation and crystallization of ribonuclease by Kunitz (1940) have permitted more accurate studies of its activity than were possible with crude preparations. A further refinement in the method of preparation developed by McDonald (1948) made possible the preparation of a crystalline product free from all measurable traces of proteolytic activity. When cytological preparations are incubated in a solution of ribonuclease it is presumed that, if given sufficient time for the enzyme to act, the nucleic acid is completely degraded and the small units diffuse from the tissue. Stowell and Zorzoli (1947) have investigated the effects of varying the fixation of the tissues and such factors as concentration of the enzyme, temperature and time of the reaction, and the type of buffering solutions, on the action of ribonuclease. These authors have emphasized the necessity for carefully controlling the conditions of the test before considering the action of ribonuclease as specific.

In considering the action of ribonuclease, it should be pointed out that chemical tests have shown that regardless of the time allowed for enzyme action, a relatively large fraction, as much as 50 per cent, of the nucleic acid is not broken into diffusible units and appears to be resistant to the action of the enzyme (Kunitz, 1940; Loring, Carpenter, and Roll, 1947; Schmidt, Cubiles, Swartz, and Tannhauser, 1947; Bacher and Allen, 1949). It has also been demonstrated by Loring et al. and Schmidt et al. and by Bacher and Allen that pyrimidine nucleotides are found more abundantly in the diffusible products, while the purine groups tend to remain in the fraction resistant to enzymatic action. Although the significance of this differential action of ribonuclease on the nucleic acid is not understood, it suggests that more than one kind of linkage binds the mononucleotides together. These findings of the chemists indicate that the cytochemist cannot interpret the loss of basophilia in a section exposed to enzyme action as necessarily indicating a complete loss of ribonucleic acid from the tissue.

Enzyme preparations which bring about a degradation of desoxyribonucleic acid have also been studied (Greenstein and Jenrette, 1941a, b; Cohen, 1945; Schmidt, Pickels, and Levene, 1939; McCarty, 1946). Although Kunitz (1948) has reported the isolation and crystallization of the enzyme, few reports on the properties and activity of the purified product have been published. Zamenhof and Chargaff (1949) have found that even after prolonged digestion of desoxyribonucleic acid with crystalline desoxyribonuclease a core of non-diffusible material remains. This enzyme has not yet been extensively used in histochemical tests, but Brachet (1946, Brachet and Shaver, 1948) used a crude preparation and reported that it causes a specific loss of basophilia from nuclear chromatin.

Another cytochemical technique which is similar in some respects to the digesting-staining procedures just discussed is one in which the large molecules are degraded by hot acid hydrolysis. Schneider (1945) found that heating macerated fresh tissues for 15 minutes in 5 per cent trichloracetic acid at 90° C. removes all of the nucleic acids. Pollister and Ris (1947) and Brachet and Shaver (1948), assuming that similar acid hydrolysis of fixed tissues would have the same effect on the nucleic acids, have utilized this procedure to remove the nucleic acids from tissue sections. They reported that all basophilic material and all substances absorbing ultraviolet light in the wavelengths characteristic of nucleic acid are removed by the trichloracetic acid hydrolysis.

Pouyet (1949) has demonstrated by chemical analysis that hydrolysis of fixed, macerated tissues with normal hydrochloric acid at 60° C. for 10 minutes will remove most of the ribose- and very little of the desoxyribose-nucleic acid. Cytochemical demonstrations that similar mild acid hydrolyses result in the loss of basophilic material from the cytoplasm without observable effects on the basophilia of the nuclear chromatin have been reported by Deane (1946) and Vendrely (1949). Ely and Ross (1949a) found that after 3 to 6 minutes of hydrolysis in normal hydrochloric acid at 60° C. all of the ultraviolet-absorbing material is gone from the cytoplasm and that a hydrolysis of 20 minutes is necessary to remove the ultraviolet-absorbing material from the nucleus. Vendrely (1949) has suggested the use of a 10-minute hydrolysis in normal hydrochloric acid at 60° C. as a substitute for ribonuclease in the location of ribonucleic acid in cells.

5. *Ultraviolet Absorption Techniques*

A technique for the detection of nucleic acids in cytological preparations, based on an entirely different principle, is that of ultraviolet light absorption. Caspersson (1940, 1947) perfected a technique for sending known wave-lengths of ultraviolet light through quartz microscope lenses focused on a portion of the cell and recording the extinction by means of a photographic plate or a photoelectric cell. Caspersson and a group of collaborators, particularly Hydén, Thorell, Engström, Norberg, Santesson, Moberger, Malmgren and Schultz, have applied this technique to a great variety of cellular problems (see Caspersson, 1947, for summary and complete bibliography). Modifications of the technique have also been utilized by other workers, particularly Pollister and his colleagues (Pollister and Ris, 1947; Pollister and Leuchtenberger, 1949a, b; Di Stefano, 1948), and by Gersh and Bodian (1943).

The technical physical problems involved in the accurate measurement of the specific absorption of light by a cellular structure have been carefully worked out by Caspersson. According to his calculations, it is theoretically possible to determine extinctions with an accuracy of 5 per cent for objects down to a size about four times the wavelength of light, that is, about 0.6 μ in the middle ultraviolet. Caspersson has constructed an elaborate apparatus which fulfills the Abbé sine condition for an optical system and insures that all light leaving the object is transferred to the image. He has also devised mathematical corrections for the non-specific losses of light in the system.

It has been shown that most organic substances found in the cell absorb heavily in the ultraviolet and that the nucleic acids have a sharply defined peak between 2570 and 2600 Å. The absorption of the nucleic acids is thought to be due to the properties of the ring structure common to both purine and pyrimidine bases. Thus, identification of these cellular components is possible by determining the absorption spectrum of ultraviolet rays. Photographs taken with light of wave-lengths in the neighborhood of 2600 Å have also been used to detect the presence of nucleotides in tissues. However, photographs cannot be considered as accurate a means of identification as complete absorption curves.

OTHER FACTORS TO BE CONSIDERED IN QUALITATIVE CYTOCHEMICAL TESTS

A prime requisite for any cytochemical technique is that the specific substance must be detectable within the cell. For the nucleic acids, this is entirely dependent on the optical properties of the substances themselves, or the reaction products. Both the basic stains and the leucofuchsin of the Feulgen reaction form colored complexes with nucleic acids which may be detected visibly, and, with the aid of a microscope, located within the individual cell. Danielli (1947) has suggested the possibility of detecting purine and pyrimidine groups by the color of the diazonium hydroxide produced after destructive benzoylation to eliminate possible reactions with other compounds. However, the ultraviolet absorption properties are usually used to detect the nitrogen bases.

It is also important to know that the color is detected in situ. As previously discussed, there has been much controversy over the diffusibility of the Feulgen reaction products. It is usually considered that the fixation and dehydration procedures precipitate or immobilize the chief cellular constituents. It is also recognized that this is accompanied by a certain amount of distortion from the fresh condition. It is to be expected that small, water- or alcohol-soluble molecules, such as simple sugars, free amino acids, dicarboxylic acids, and mononucleotides, will not be fixed and will tend to diffuse from the cell during the process of fixation and dehydration. At the present time, no good way of circumventing these difficulties has been devised.

Since one of the objectives of cytochemical studies is to supply information which may be used in interpreting the functions of living cells, it is important to consider the relationship between the condition of the living cell and the condition of the cell when the test is made. The nature of most of the present cytochemical tests is such that either the cell is killed before starting the procedure or the technique itself damages the cell. Even microscopic observation of normal living, differentiated cell types has been limited by the technical difficulties of making suitable preparations. Furthermore, the criteria for a "good" preparation have not always been derived from a study of living cells but from a standardized picture of what the early cytologists found when they studied fixed material. For example, the living nucleus usually presents a more or less homogeneous appearance in which only the nucleolus is observed as a formed body. Nevertheless, the "typical" cytological nuclear picture is one in which the chromatin is localized into discrete clumps. Furthermore, even though care may be taken to use those procedures which preserve the cellular structures in a condition which optically most resembles the living cell, this cannot be regarded as an adequate indication that the chemical characteristics have not been altered. There is no completely adequate way of knowing the chemical or physical changes undergone by the protoplasmic components during death from various causes, and hence, how closely the test conditions correspond to those of the living cell.

Only a few isolated observations comparing the reactions between living and dead protoplasm have been reported. Michaelis (1947) pointed out that the nucleus of a living cell does not stain at all in a dilute solution of dye of sufficient strength to stain the dead cell. He suggested that on death some irreversible change occurs in the nucleoprotein, so that acid groups, formerly bound, are now free to react with the basic dye group. Ely and Ross (1949a) found that living cells resist the action of desoxyribonucleic acid depolymerase, although the enzyme attacks cells killed by heat, fixatives, and ultraviolet light. It is possible that in both of these cases the permeability of the cell, or nuclear, membrane plays an important role in preventing the substances from coming into actual contact with the nucleic acids of the cell. On the other hand, it is also possible that the explanation is to be found in a different chemical or physical condition in living protoplasm.

Differences in the ultraviolet absorption properties of living and dead cells have also been reported. Brumberg and Larionov (1947; Larionov and Brumberg, 1948) found that the nucleus of a living cell does not absorb ultraviolet. They demonstrated that a relatively short exposure of living cells to ultraviolet rays kills the cell and that the absorption by the nucleus then increases, whereas that of the cytoplasm decreases. Recent investigations of Ris and Mirsky (1949) have verified Brumberg and Larionov's observations. On the other hand, Ludford, Smiles, and Welch (1948) and Ely and Ross (1949b) found that living cells show strong absorption when first observed. Bradfield and Errera (1949) found that as ultraviolet radiation is prolonged different kinds of cells behave in different ways; in some the absorption increases, in others it decreases, and in some it shows little change. Although the significance of these observations of ultraviolet absorption by the cell is not clearly understood, it seems apparent that, in some types of cells at least, there is a difference in the capacity of living and dead protoplasm to absorb ultraviolet rays.

It has long been known that different histological fixatives produce great variations in the optical appearance and stainability of cells. At first the choice of fixative to be used was largely empirical; experience showed that certain fixatives give "good" results with certain stains and tissues, while others do not. With progress in biochemistry, the reasons for the observed effects began to be more clearly understood. Since nucleic acids are unstable in alkaline solutions, they would not be expected to be retained in cells fixed at a high pH. This corresponds with the observation that most good nuclear and cytoplasmic basophilic fixatives contain a relatively high concentration of acetic acid.

The effect of chemical reactions on the amphoteric properties of proteins should be kept in mind in using staining or cytochemical reactions. It has been shown that formaldehyde reacts with the amino groups of proteins and hence tends to cause a shift of the isoelectric point toward the acid side. Likewise, fixation with salts of heavy metals tends to shift the isoelectric point to the alkaline side by rendering the carboxyl groups non-dissociable (Baker, 1945; Dempsey and Wislocki, 1946; Kelly and Miller, 1935a). Thus the affinity of the proteins for basic or acidic stains will vary with the fixation.

In addition to the effects of fixatives on the staining qualities of proteins, those who use histochemical procedures that employ enzyme or acid hydrolytic action on nucleic acids should consider the possible effects of the fixatives on the bonding of the nucleic acid and nucleoproteins. The data concerning ribonuclease digestion techniques compiled by Stowell and Zorzoli (1947) and Lillie (1949) show that following a large number of fixatives enzymatic action results in a loss of basophilia while certain other fixations apparently render the tissues completely resistant to the action of the enzyme. Thus, in using the digesting-staining techniques, care should be taken to select a fixative which will not prevent the enzyme from hydrolyzing the nucleic acid.

Problems such as these arise from the fundamental complexity of the protoplasmic system. Obviously, in checking the validity of a cytochemical test, it is not sufficient to demonstrate that test-tube reactions between reagents and purified substances will occur, for in the cell many factors, difficult to control and usually not precisely known, may be involved in the reaction. This necessitates a continual guard against too great a confidence in any one procedure, along with never-ending effort to obtain a more complete understanding of the chemical and physical nature of the cell.

QUANTITATIVE TESTS

Although cytochemists have been chiefly concerned with the detection and location of the two types of nucleic acid, some attempts have been made to adapt the techniques previously discussed to permit quantitative measurements. Essentially the methods consist of using sensitive photoelectric cells to measure the amount of monochromatic light of a specific wave-length which is absorbed by the nucleic acid or by the dye-nucleic acid complex. The absolute extinction value is usually compared with a control measurement of the extinction in adjacent non-colored regions or by measuring the extinction in an area from which the nucleic acids have been removed by hot acid or enzymatic hydrolysis.

The ultraviolet absorption techniques developed by the Caspersson school have been most widely utilized for making quantitative determinations. Caspersson has emphasized the necessity for a rigid control of the physical conditions of the optical set-up (1940, 1947). He has also commented on the fact that the validity of the technique is dependent on the optical properties of the object measured (1947). Caspersson and all those others using this technique have assumed that the relation between the amount of light absorbed and the number of molecules of the substance follows the Beer-Lambert law. Commoner and Lipkin (1949) have shown that theoretically this law may not hold, if the nucleic acid molecules are oriented. Furthermore, Commoner (1949) has pointed out that nucleic acids organized in the form of a cell structure may be sufficiently oriented to cause significant departures from the Beer-Lambert law.

Procedures which measure the extinction of monochromatic visible light of appropriate wave lengths by structures colored by the Feulgen reaction or by basic staining have been devised by Stowell (1942, 1946b; Stowell and Cooper, 1945); by Pollister and Ris (1947), and Kurnick (1950b). The problem of molecular orientation just discussed is also present here. It is necessary for it to be demonstrated that the Beer-Lambert law holds in the specific preparation being analyzed. These techniques are also complicated by the difficulty of determining the number of reacting groups on the nucleic acid molecule which are involved in the dye binding.

CONCLUSION

The commonly used cytochemical techniques for studying nucleic acid, namely, the Feulgen reaction, basic staining, basic staining combined with enzymatic or acid hydrolysis, and ultraviolet absorption, have been discussed in terms of the criteria of a valid cytochemical test. The evidence indicates that under properly controlled conditions the tests are adequate for detecting and locating the nucleic acids in cytological preparations. Nevertheless, the complexity of the conditions under which the cytochemist works is such that it is necessary to maintain a critical attitude toward the procedures used and the conclusions drawn from the observations.

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DEVELOPMENT AND MEDUSA-BUD FORMATION IN THE HYDROMEDUSAE

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INTRODUCTION

THE Hydromedusae or Hydrozoa are usually conceived as coelenterate organisms alternating between a sessile hydroid phase which reproduces asexually to form medusae, and free-swimming medusae which reproduce by means of fertilized eggs, the eggs developing into planula larvae which settle and grow into hydroids. This is true enough of the majority of forms which constitute the Hydromedusae, and even of some of the Scyphomedusae. There has been a relative lack of emphasis upon the reproductive capacities of medusae as such, as distinct from their role in settling shallow water regions as hydroids and the production of new medusa swarms by those hydroids. This is undoubtedly a reflection of the comparative ease with which sessile hydroids can be studied from coastal laboratories, and the difficulties of investigating the activities of purely pelagic organisms.

The following review represents an effort to bring together what is known concerning the developmental cycles of medusae as they occur beyond the reach of shore or floor of the sea. The interest lies mainly in two activities, the development of medusa eggs directly into new medusae, and the processes of budding by the medusae themselves. Both of these refer to the maintenance of medusa populations within the ocean currents, drifting with the flow as far as it can carry them, until changing temperature or food supply puts an end to the migration. The hydroids, on the other hand, constitute a seedstock to windward. Four orders of the Hydromedusae are generally recognized, the Trachymedusae, Narcomedusae, Anthomedusae, and Leptomedusae, with some greater distinction being drawn between the two pairs than between the respective members of each pair. The adult taxonomy, however, does not concern us here, although it obviously has a large place in any adequate discussion of the question of the monophyletic or polyphyletic origin of medusae.

Development and budding are described in the following sections for each of the four orders separately, partly because the diversity and variability existing among and within them make a straight comparative account too complex, and partly to emphasize the parallelism that clearly exists between them.

Many of the accounts reviewed are old, accurate, detailed, and lost from contemporary literature. Others are recent, but in many ways, if we discount the interpretation of the times, the oldest are descriptively and illustratively the best; this refers especially to the monographs of Louis Agassiz, Metschnikoff, and not least, Alfred Goldsborough Mayer.

I. TRACHYMEDUSAE AND NARCOMEDUSAE

The size of the eggs of the Trachymedusae varies only within certain rather narrow limits, from the small egg of *Aglaura* of diameter 0.09 mm. to that of *Geryonia* with a diameter about three times as great. Even so, the volume difference is about thirtyfold. The size range for the eggs of the Trachymedusae is in fact much the same as that of the Scyphomedusae (cf. Berrill, 1949b), except that none appear to have as small an egg as that of *Haliclystus* and *Luncernaria* (0.03 mm. diameter).

In Fig. 1, the developmental stages of *Aglaura*, *Liriope*, and *Geryonia* are drawn to the same scale. *Liriope* and *Geryonia* may be the more directly compared. Even though the egg of *Geryonia* has twice the diameter and eight times the volume of *Liriope*, the cleavage and subsequent development of both are practically the same. In both, cleavage is total and equal, and the blastula is converted into a gastrula by delamination of the inner ends of all the cells to form an inner endodermal layer. A medusa develops directly in each case through continued and apparently uniform growth of the inner and outer spheres of cells. That is, with regard to the original polar axis of the egg, there is as much expansion in the transverse plane as along the polar axis. The planula-like nature of the larva which is formed from isolated 8-cell or 16-cell blastomeres may result from the reduced size of the cleaving mass, though it seems more likely to be caused by the essentially polar organization, which extends from the center to the periphery of the intact whole embryo and is dominant in isolated cells.

In any case, the direct development of the medusa of *Liriope* and *Geryonia* conforms well with the correlation shown for the Scyphomedusae with respect to egg size and its consequences. It is more difficult to account for the direct development in the case of *Aglaura*. The egg is not only remarkably small for one that undergoes direct development, but the epibolic overgrowth of the vegetal by the animal blastomeres represents an intense polar organization, in strong contrast to the preceding cases. The development of tentacles to form a small transient actinula stage in advance of the final elaboration of medusoid organization is strongly reminiscent of the narcomedusal type of development. In fact, there is more than a suggestion of heterogeneity within the Trachymedusae, and the sharp distinction between the medusoid orders based upon adult characters becomes progressively vague as the organisms become considered in their entirety in space and time.

Gonionemus (Fig. 2) has a small egg of a size typical of those which develop into planulae. In spite of the fact that the endoderm is formed by a regular delamination comparable to that of *Geryonia* and *Liriope*, the embryo elongates along its polar axis to form a planula, instead of developing directly to form a young medusa. The development of the egg of *Craspedacusta* (Fig. 3) is in general very similar, in so far as it is known, the main difference being in this case the more or less polar ingression of cells to form the endodermal mass.

In both *Gonionemus* and *Craspedacusta* a minute sessile polyp develops, one with tentacles and one without. In both cases a series of elongated buds are produced from the lateral body wall; they have acquired the rather unfortunate name of 'frustules.' They are essentially stolon-like outgrowths which become constricted off from the parent when about four or five times as long as they are wide. The epidermis and endodermis appear to be equally involved in their formation. A remarkably similar production of lateral elongated buds occurs during early stages in the life cycle of *Haliclystus* and *Lucernaria* among the Scyphomedusae (cf. Berrill, 1949b, c), and also in the Narcomedusae.

Under certain conditions, at least partly related to late growth and season, *Gonionemus* and *Craspedacusta* polyps produce buds which develop a medusoid organization before they are set free. In both forms the essential structure in this development is the formation of an entocodon (glockenkern, medusa-bell), something which is universally characteristic of medusa development throughout the orders Anthomedusae and Leptomedusae, but is absent in the Narcomedusae and the Scyphomedusae. The marine *Gonionemus* is the more typical in this respect. The two freshwater forms, *Limnocnida* and *Craspedacusta*, are remarkable in that the entocodon arises in the one as an open invagination of the distal epidermis of the medusa bud, and in the other by a process recognizably the same. This is in contrast to the origin of the entocodon in the Anthomedusae and Leptomedusae, an origin by delamination from a solid mass of tissue, of ectodermal origin in some, endodermal in others (Liu and Berrill, 1948).

Little is known concerning the early embryonic development of the Narcomedusae as a whole, and egg size and cleavage patterns are recorded only for *Solmaris* and *Solmundella*. A comparison of the early development of the trachymedusan *Aglaura* and *Liriope* with that of *Solmaris* is of some interest. In the case of *Aglaura* and of some eggs of *Solmaris*, the third or horizontal division is unequal, and the animal-pole cells overgrow the vegetal by a process of epiboly to form the two-layered gastrula. On the other hand, in the case of *Liriope* and of other eggs of *Solmaris*, the third cleavage is an equal one, and the gastrula in each of these is attained by central delamination of the inner ends of the cells of the blastula. It is probably incorrect to suppose that the difference in mode of endoderm formation is a consequence of inequality or equality at the third cleavage. It is more likely that inequality and epiboly are both expressions of a relatively intense polar organization of the cleaving egg. In spite of the extraordinarily large size of the egg of *Solmaris flavescens*, the largest recorded for any medusa, the eggs develop much as do the much smaller eggs of *Solmaris leucostyla*, exhibiting the same variability in cleavage and gastrulation. The experiments of Maas (1902), on 8- to 12-cell embryos showed definitely that a marked differentiation already exists at that stage along the polar axis.

The eggs of both *Solmaris* and *Solmundella* (Fig. 4) develop into medusae without passing through a sessile stage of any form. Whether cleavage has been equal or unequal, a planula-shaped embryo is produced before the medusoid form develops. In *Solmaris* one end of the embryo develops a bell margin and tentacle rudiments, not unlike the mode of development of *Aglaura*, and markedly different from that of *Liriope* and *Geryonia*. Both Brooks (1886) and Mayer (1910) regarded this type of development as one involving the transient formation of an actinula, that is, a non-attached hydra-like organism. The elongate planula-shaped larva of *Solmundella* is more difficult to interpret, for it is the central region which develops into the body of the medusa, and the two ends survive as the two tentacles of the adult. The limitation of the final tentacle number to two has undoubtedly impressed itself upon the course of early development.

The other Narcomedusae have a more complex developmental history, in part due to a parasitic phase, in part to an alternation of sexual and asexual methods of reproduction. It is not always clear which has been the origin of a particular medusa, but species of *Pegantha*, *Cunina*, and *Cunoctantha* (Figs. 4–6) do appear to have eggs which are modified in relation to the parasitic faculty. The eggs are in each case accompanied by a nurse cell that appears to nourish them during the early stages of cleavage, and the eggs at the time of fertilization are little if any larger than most kinds of tissue cells, that is, the usual size of oocytes before the onset of the growth phase.

Growth of course is necessary before anything approaching the medusoid or any other organization can be expressed, but the remarkable fact here is that such growth occurs after instead of before the onset of development of the egg. It is, however, only an assumption that the relatively minute size of the eggs (less than 10 microns diameter) is a secondary response to a form of parasitism. It is a possibility that should not be overlooked that we have here a survival of a primeval type of egg, a survival made possible only by the peculiarities of its special environment.

The primary embryo of these Narcomedusae may develop directly into a medusa, or by way of an actinula, parasitic on other medusae, which produces secondary medusae by means of aboral buds; or into a proliferating mass that subdivides, as for example in the polyembryony of certain bryozoans, to form numerous presumptive medusa buds. The variability of the budding site, as illustrated at least by the aboral budding stolon of *Cunoctantha octonaria* (Fig. 6), the external wall of the stomach pouches of *Cunoctantha fowleri*, and the inner lining of the gastric cavities of *Cunina peregrina* and *Pegantha clara*, suggests a multiple origin of the process. Aboral budding of actinulae and of immature medusae of *Cunoctantha* and *Cunina* may be homologous, the differences reflecting a temporal distinction, but the three sites referred to above appear to be basically distinct, and budding accordingly appears to be polyphyletic.

In all of the Narcomedusae known to produce medusae by budding, directly or indirectly, the process of budding is associated with the earlier developmental stages. Buds are produced the most rapidly in those forms in which they are produced soonest in the growth cycle as a whole, e.g., rapidly in internal budding, more slowly in juvenile stages, e.g., by actinulae, and more slowly again in immature medusae. The attainment of sexual maturity appears to follow the cessation of the budding activity. This should not be regarded as an incompatibility between the two types of reproduction, which in fact are not always disassociated, but as an inverse correlation. Budding is associated with active growth, occurs in direct proportion to the rate of growth, and ceases as growth slows to an end. Sexual maturity on the other hand develops with the attainment of near-maximum size or with cessation of growth.

While some Narcomedusae do not seem to have a parasitic phase in their life cycle, e.g., *Solmaris* and *Solmundella*, the majority of those of which the life cycle is known with some degree of completeness do have such a phase. It is a purely pelagic association, for the most part between medusa and medusa, and even when the host is an annelid it is the pelagic genus *Tomopteris*. Only in the case of the ubiquitous *Polypodium*, parasitic in the eggs of the sturgeon, do we have a benthic animal involved, and the incompleteness of this fantastic story leaves much to conjecture.

In a general way there seems to be a degree of specificity between parasite and host forms, but it is none too definite and may in part at least be due to propinquity of species in space and time. The parasitism itself appears in two forms. There is a more definite and obvious parasitism, such as that of *Cunoctantha octonaria* on *Turritopsis*, and the less tangible form where medusae develop free in the gastric cavities of the parental or some other medusa, in which they obtain nourishment from the liquid gastrovascular medium of the host.

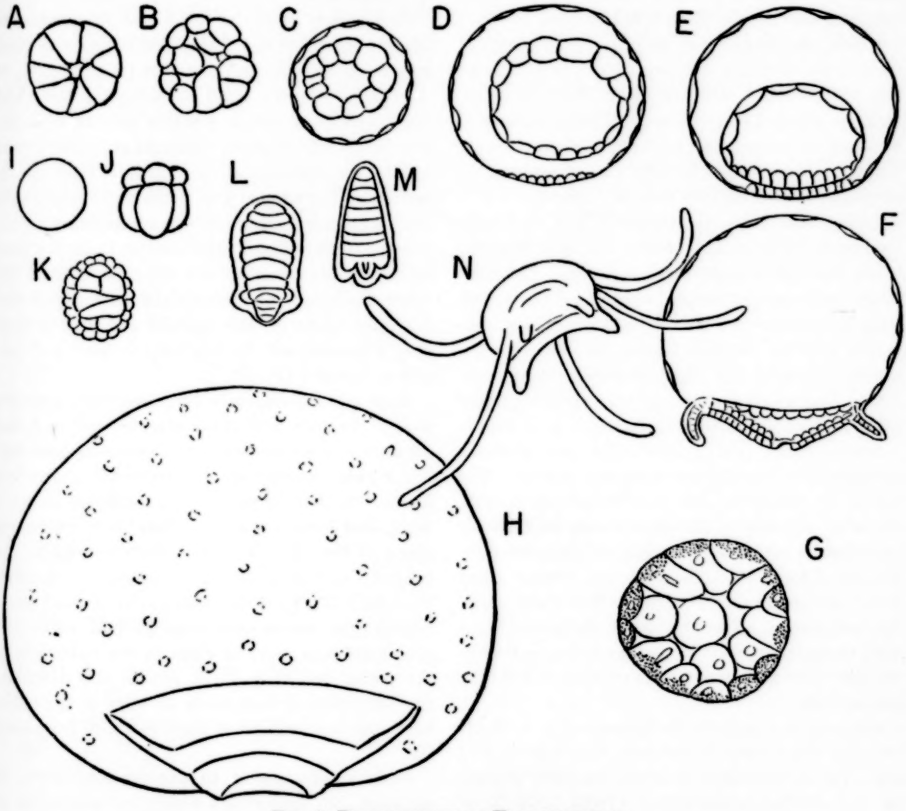

FIG. 1. DEVELOPMENT OF TRACHYMEDUSAE
Family Geryonidae: A–F, *Liriope mucronata;* G–H, *Geryonia proboscidalis.*
Family Trachynemidae: I–N, *Aglaura hemistoma.* (After Metschnikoff.)

The developmental history of the trachymedusans and narcomedusans for which it is known is given below in more detail. In most cases there is a novel interest that does not lend itself well to a comparative account.

Trachymedusae

Aglaura hemistoma Peron and Lesueur (Fig. 1, I-N). According to Metschnikoff (1886), the comparatively small egg (0.09 mm. diam.) of *Aglaura hemistoma* develops in a semi-direct manner into a medusa. Cleavage is total but unequal, and the 8-cell stage consists of 4 micromeres and 4 macromeres. The larger cells become the endoderm and are enveloped by the micromeres through a form of epiboly, and a solid planula develops. The planula is elongated and the endodermal cells form a single row. The ciliated free-swimming larva develops tentacles. The first indication of this is a proliferative activity of endodermal cells in a transverse plane near one end of the planula, and a pair of tentacles emerges, followed by a second and intervening pair a little later. In fact, a small actinula or hydra-like form is produced, with 4 tentacles around a terminal manubrium and mouth (Fig. 1, M). Lithocyst clubs, which appear essentially to be modified tentacles, then grow out between the tentacles. The bell margin, that is, the swimming organ of the adult, appears last of all, as an outgrowth of the expanding rim between the bases of the tentacles and lithocyst clubs.

The development of the related form, *Rhopalenema velatum* Gegenbaur, which has the more usual egg size of 0.24 mm., is not known.

Among the Geryonidae, only the development of *Liriope* and *Geryonia* is known. Neither form has an egg exceptionally small or large. Their development is much alike, the only obvious difference between them being the production of six primary tentacles from the relatively larger embryo of *Geryonia*, compared with four in *Liriope*.

Liriope mucronata (Gegenbaur (Fig. 1, A–F) was studied by Metschnikoff (1886). The egg, diameter 0.135 mm., undergoes total and equal cleavage, while the innermost ends of the cells of the 16-cell stage delaminate to form the endoderm. Jelly is secreted between the two layers, the ectoderm becomes ciliated, and the embryo consequently swims. Continued secretion of jelly virtually forces the endodermal vesicle towards one pole of the ectodermal vesicle (Fig. 1, E, F). The mouth breaks through and four short tentacles appear. The velum is primarily an ectodermal outgrowth. Whether any stage in this process may legitimately be called an actinula is a matter of interpretation. Brooks (1886), working with the closely allied American species *Liriope scutigera* McCrady, found its development to be practically the same. Eight solid tentacles are formed, and according to Brooks the peristome in a sense pushes inwards to form the subumbrella.

Geryonia proboscidalis Eschscholtz (Fig. 1, G–H) has eggs which vary in diameter from 0.23 to 0.33 mm., the development of which has been studied by Fol (1873), Metschnikoff (1886), and Maas (1908). The general development is essentially similar to that of *Liriope*, and it is notable that there is the same delamination of the inner ends of the blastula cells of the 16-cell stage to form the endodermal vesicle. According to Maas, the undivided egg has a cortical layer of fine cytoplasm, an inner layer exhibiting a foam structure, and a central gelatinous region. This conforms well with the delaminating segregation (Fig. I, G). Maas also found that isolated 2-cell blastomeres give rise to perfect medusae, but that cells isolated at the 8- or 16-cell stage yield larvae much more like planulae.

It is notable that the whole egg of *Aglaura* has a volume less than an isolated blastomere of the 8- or 16-cell stage of *Geryonia*, and both its form of cleavage and epibolic manner of gastrulation indicate a polar organization more comparable with the isolated blastomere than with the whole egg of *Geryonia*.

Gonionemus (Fig. 2, A–L) and *Craspedacusta* Mayer, according to Perkins (1903), produce small eggs of about 0.07 mm. diameter (not 0.7 mm., as quoted by Mayer, 1910). Cleavage is total and equal and gives rise to a hollow ciliated blastula. The inner ends of all the blastula cells delaminate to form the endoderm, at a stage later than the 32-cell stage. Increase in size of the endodermal cells thus segregated results in the obliteration of the internal cavity. The larva elongates to form a free-swimming planula with one end broader than the other, the broad end becomes attached, mouth and tentacles appear at the opposite end, two at first, then a second pair. In this form it feeds and persists as a hydra (Fig. 2, D).

Buds are subsequently produced from near the base of the body wall of the attached polyp. A bud appears as a simple outgrowth involving both layers. Perkins found that the outgrowth of the bud up to the time of constriction occupied about 5 days, that there was a non-ciliated motile creeping phase of from 2 to 4 days, and that tentacles appeared 3 to 5 days after reattachment. According to Joseph (1925), while both epidermis and endodermis grow out to constitute the bud, active cell proliferation is more obvious in the epidermis of the young bud (Fig. 2, J). Joseph also described the formation of buds from all sides of the polyp base, and a succession of buds given off from each site.

Perkins was unable to observe the origin of medusae, but suspected a direct transformation of the polyp into a medusa. Joseph, however, found that medusa buds are produced from the body wall of the polyp at sites similar to those forming the planula-like buds, although apparently during the later growth phases of the polyp. The epidermis and endodermis both take part in this case also, but the terminal activity of the outgrowth appears to be different. Proliferation of the center of the distal end, especially of the epidermis, is much more intense, and it is fairly clear from Joseph's figures that a typical epidermal entocodon is produced as the initial stage in the formation of the medusa (Fig. 2, L). There is obviously no outward thrust of endodermis as in the first type of bud, and growth is relatively tangential.

Limnocnida tanganicae (Fig. 2, M–P) is another freshwater form, assigned to a family of its own among the Trachymedusae. In this case neither the development of the egg nor the nature of the hydroid is known. Medusa buds, however, are produced on the outer side of the rim of the stomach wall, involving both epidermis and endodermis. They pulsate before being set free. Sometimes budding stolons grow out. Gonads develop only after budding has ceased.

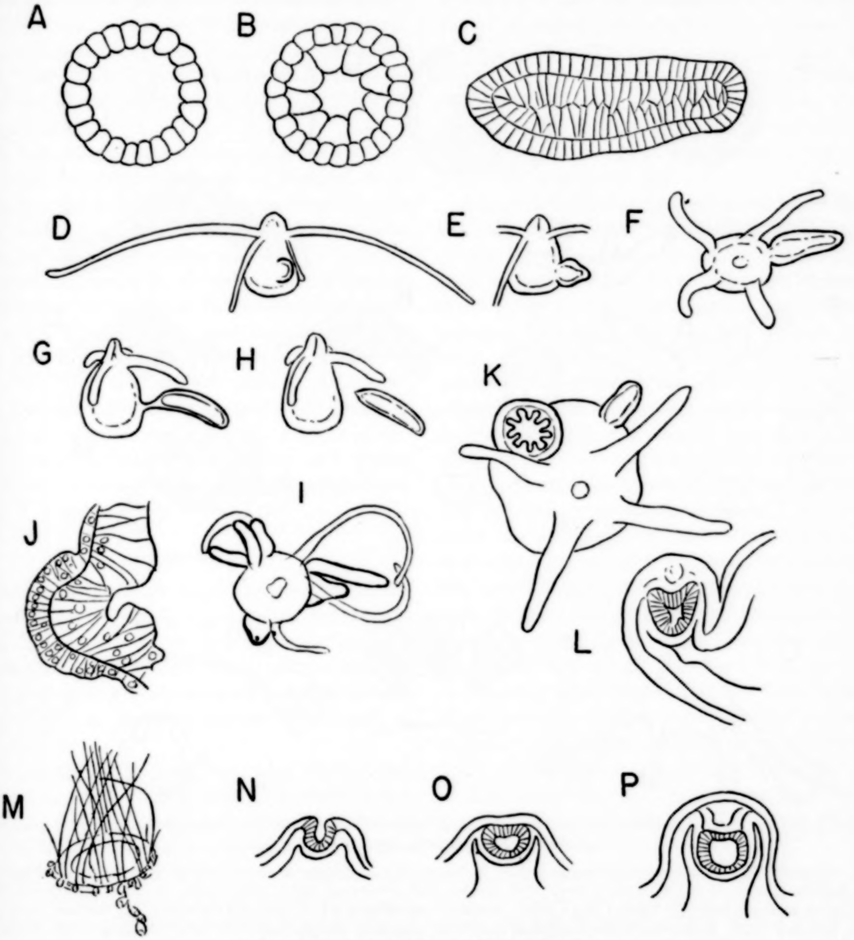

Fig. 2. Development of Trachymedusae

Gonionemus murbachii (Olindiadae): A–C, segmentation, delamination, and panula; D, initiation of lateral bud; E, same one day later; F, four days later; G, H, another bud at a 15 minute interval; I, formation of multiple lateral buds from young hydranth; J, section through bud rudiment; K, older hydranth with both a lateral planula bud and a larger medusa bud; L, section through medusa bud showing advanced entocodon. (A–H, after Perkins; I-L, after Joseph.)

Limnocnida tanganyica (Limnocnididae): M, young medusa, showing marginal medusa buds; N, formation of entocodon by distal invagination; O, P, later stages in medusa formation. (After Boulenger.)

Medusa buds are formed in essentially the same way as in *Craspedacusta*, involving the formation of an entocodon and a typical subsequent development. The unique feature lies in the mode of development of the entocodon itself. This structural unit is in any case the basis of the essential tetraradial organization of the medusa, but in all other cases it arises from a solid mass of distal epidermal tissue. In this instance (cf. Boulenger, 1911) the central distal region of the outgrowth actually invaginates, and the invagination subsequently constricts off as a subepidermal vesicle, the entocodon (Fig. 2, N, O, P). This is not necessarily the most primitive method, but in a developmental sense it is the simplest and most understandable. The procedure in *Craspedacusta*, however, is only a little removed, for while no open invagination is present, the invagination is discernible as a downgrowth from the distal center.

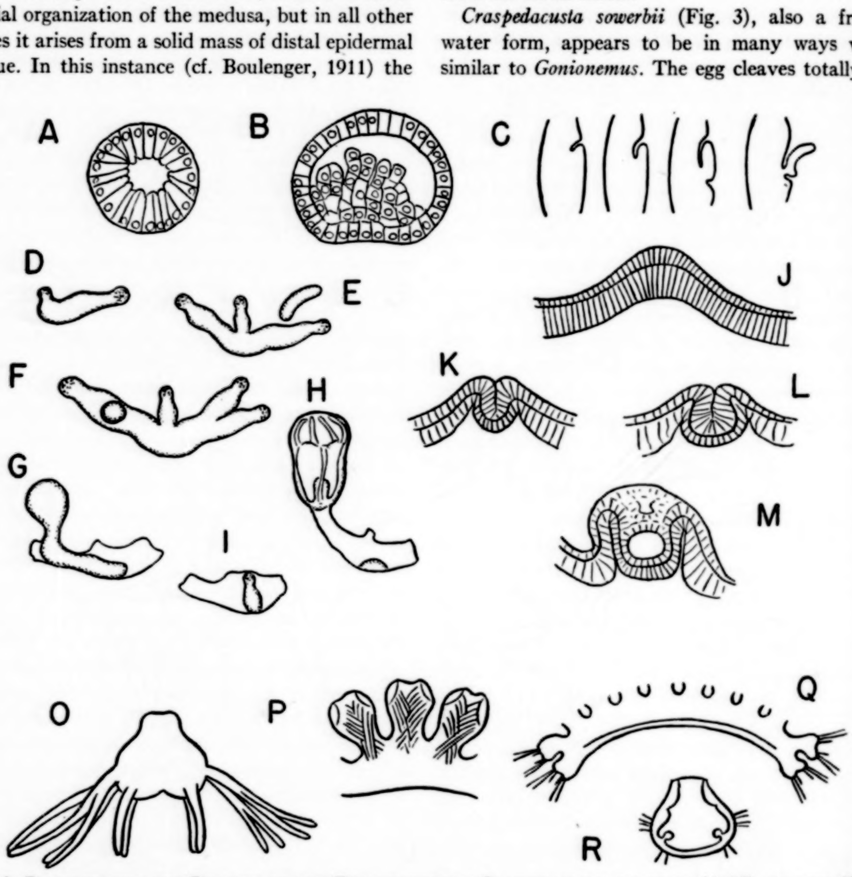

FIG. 3. DEVELOPMENT AND BUDDING IN THE TRACHYMEDUSAN CRASPEDACUSTA SOWERBII (A–M) AND THE NARCOMEDUSAN POLYPODIUM HYDRIFORME (O–R)

C. sowerbii: A, B, blastula and gastrulation; C, formation and separation of lateral bud from hydranth; D, 2-hydranth colony; E, 3-hydranth colony with lateral bud separated, three days later; F, same colony six weeks later with medusa bud; G, twelve days later, medusa bud advanced, hydranths resorbed; H, medusa bud complete, one day later; I, five days later, medusa liberated, remnant reorganized into new hydranth; J–M, initiation of medusa bud and formation of entocodon by virtual invagination. (After Payne.)

P. hydriforme: O, free polyp in walking position; P, part of budding stolon within a sturgeon egg, with three inverted polyps; O, stolon showing terminal polyps and bases of others, with basal split anticipating eversion; R, section through older polyp showing small gonads. (After Lipin.)

Craspedacusta sowerbii (Fig. 3), also a freshwater form, appears to be in many ways very similar to *Gonionemus*. The egg cleaves totally to form a hollow blastula and is converted into a planula by a broad ingression from one pole (Payne, 1926). The hydroid or polyp stage, originally call *Microhydra ryderi*, was long suspected to be the progenitor of the medusa *Craspedacusta*, and Payne (1924, 1926) finally followed through the complete life cycle. The polyp differs from that of *Gonionemus* in the absence of tentacles and in the tendency of buds to remain attached together to form simple colonies. Buds are produced which are set free, however, and have the same capacity of non-ciliated migration. The manner of formation and segregation of the bud is somewhat distinctive, and consists of a more or less longitudinal constriction of the end from the long axis of the polyp (Fig. 3, C). The bud finally constricts off from the basal part of the polyp and is essentially like that of *Gonionemus*.

Medusa buds appear late in the growth season, and from the lateral wall, never by terminal transformation. Once initiated a bud continues to grow until development is complete, even at the expense of resorption of the feeding zooids (Fig. 3, F–H). Residual fragments of the colony tissue may reconstitute a polyp (Fig. 3, I). The outgrowth leading to the formation of a medusa bud consists of both epidermis and endodermis, as in the case of the other types of buds, but again as in *Gonionemus*, the central distal epidermal proliferation is much more intense than that of the adjacent endodermis, and the epidermis segregates as a typical entocodon, thereby initiating medusa organization (Fig. 3, J–M).

Narcomedusae

The Narcomedusae have lithocysts of endodermal origin like the Trachymedusae, but the ring canal is not well formed and is subject to great variability in development. There are two families, the Solmaridae, without stomach pouches, and the Aeginidae, with marginal pouches in the radii of the tentacles.

Two species of *Solmaris* have been studied. According to Metschnikoff (1886), *Solmaris leucostyla* Haeckel produces eggs with a diameter of 0.127 to 0.147 mm., which undergo total cleavage. Cleavage may be equal or unequal. Equal cleavage leads to the formation of a solid morula which delaminates centrally. In the case of unequal cleavage, a comparable result is obtained by epiboly.

Solmaris flavescens (Kölliker), according to Maas (1902), in spite of a large egg size varying from 0.8 to 1.5 mm. diameter, develops in the same way as *S. leucostyla*. The third or horizontal cleavage may be equal or unequal. In the case of equal cleavage, the inner ends of the morula cells delaminate, and an oval planula is formed. Jelly is secreted at the upper end between the two layers thus produced, separating the exumbrellar ectoderm from the subumbrellar endoderm. Tentacles grow out from the margin as wide basal bulbs. The bell margin itself grows beneath and between the tentacles, and the mouth finally breaks through.

Blastomeres isolated at the 2-cell stage form apparently normal planulae and medusae. The 8-cell stage, separated into small 4-celled animal and large 4-celled vegetal tiers of cells, gives rise to a small degenerate and a large, irregular embryo respectively. On the other hand, the 8- to 12-cell stage cut meridionally gives rise to more or less normal medusae. There is evidently a polar organization axis in the egg.

Solmundella bitentaculata var. *mediterranea* Haeckel (Fig. 4, O–S), also studied by Metschnikoff (1886), has eggs of diameter 0.23 mm. Cleavage is total and equal. After the 16-cell stage, endoderm is formed by a very general kind of multipolar ingression, with cells migrating from almost every point into the interior to fill it up. The larva then elongates, the ectoderm becomes ciliated, and the whole resembles a detached tentacle of some hydroid. The endodermal cells at both ends become disk-like and are set in a single row, with the two parts separated by a parenchymal central mass. The two ends form two tentacles, and the center forms the body of an actinula larva, which is at first mitre-shaped, with two long stiff tentacles. The mouth breaks through and a digestive cavity forms in the center of the parenchymal mass. Jelly forms above the digestive cavity between the two layers. The bell margin grows out from the sides of the larva *after* the actinula has been formed. While the early ciliated larva resembles a greatly elongated planula, this appearance seems to be the result of precocious tentacle formation, and the peculiar conformation is owing to the limitation of the final number of adult tentacles to two (Fig. 4, O–R).

Reproduction in two species of *Pegantha* has been described by Bigelow (1909). In *Pegantha smaragdina* H. B. Bigelow (Fig. 4, F–K), the eggs are of endodermal origin and develop in the exumbrella of the parent near the margin of the gastric cavity. Each egg is associated with an ameboid cell that divides amitotically. This is the nurse cell, and its importance is emphasized by the smallness of the egg itself. The egg, in fact, is almost unbelievably small, and while Bigelow did not give actual dimensions, his illustrations drawn to scale indicate a diameter of 7 or 8 microns, hardly larger than ordinary tissue cells (Fig. 4, F).

The egg cell divides completely and gives rise to

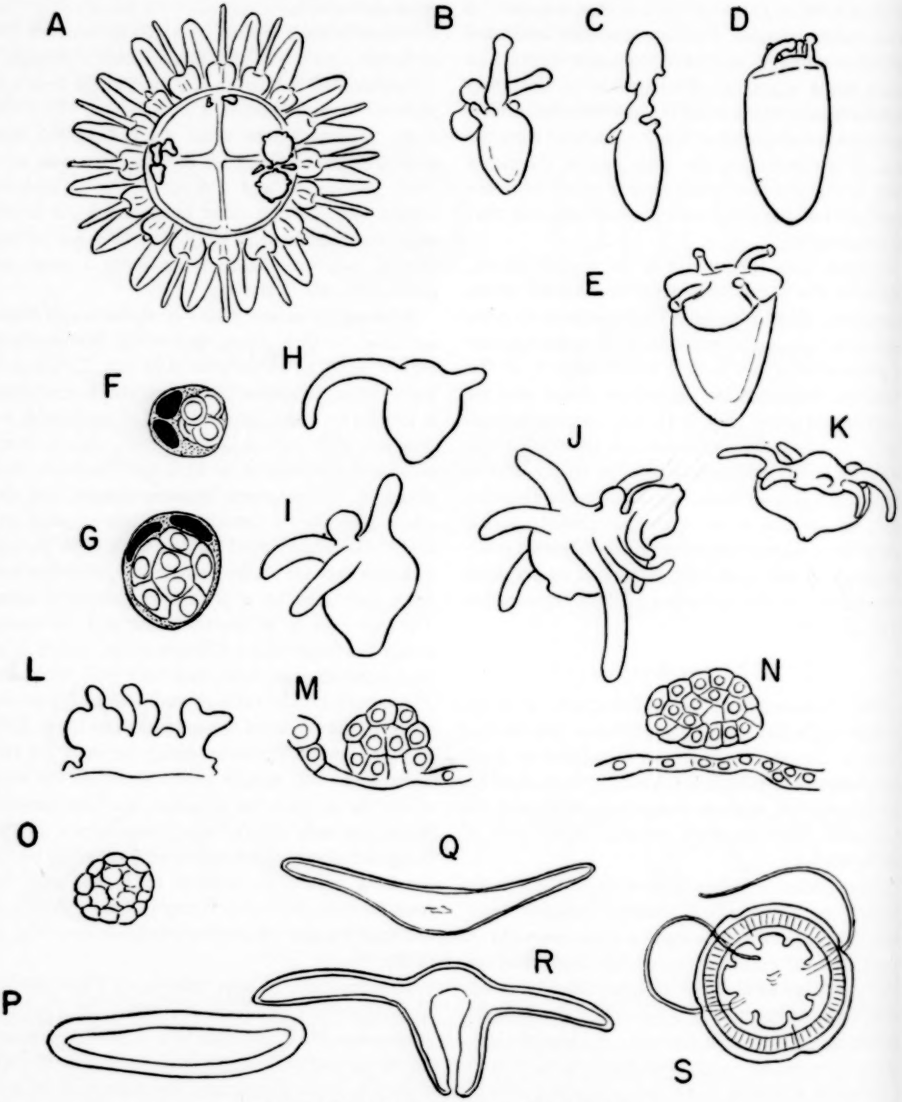

FIG. 4. DEVELOPMENT OF THE NARCOMEDUSAE

Pegantha clara: A, medusa of *Periphylla* with polyps and medusae of *P. clara* in gastric cavity; B, primary polyp or actinula with tentacles and buds; C, bud becoming an actinula and producing a bud chain; D, E, transformation of actinula into medusa. (After Kramp.)

Pegantha smarygdina: F, 4-cell stage, together with nurse cell; G, 2-layered embryo with nurse cell; H, developing actinula; I, actinula with tentacles and bud; J, actinula with bud forming and with first bud in actinula stage; K, medusa ready for liberation. (After Bigelow.)

Pegantha laevis: L, M, N, proliferating mass, bud forming and bud set free, in internal budding from gastric lining. (After Bigelow.)

Solmundella bitentaculata: O, cleavage in egg; P, elongate embryo; Q, R, transformation of embryo into 2-tentacled larva and actinula, respectively; S, mature form. (O–R, after Metschnikoff; S, after Mayer.)

a solid morula (Fig. 4, G). As individual cell size is maintained, growth must accompany progressive cell division. The larva penetrates the endodermis and comes to lie in the parental gastric cavity, losing the nurse cell in the process. Larval endoderm is formed by secondary delamination, however, before the migration occurs. The planula-like embryo, about 30 microns long, develops into a more elongated larva with a chordate endoderm, similar to the tentacle-like larva of *Solmundella*. Its development is somewhat different, for a mouth appears at one end, and the bulk of the larva forms the primary tentacle, not the pair of tentacles as in *Solmundella*. A second tentacle develops opposite the first, and others in between at a later stage (Fig. 4, H).

When larvae have acquired four or more tentacles, they usually commence to bud, and at this stage are very numerous, lying in the canal system of the parent-host. Budding occurs at the aboral pole and involves both layers. A bud may separate from the parent larva while still a mere sac or remain attached until it in turn possesses tentacles and a mouth at its distal end. Only one or two buds are in process of formation at one time.

Buds thus produced develop or metamorphose into medusae. A bell margin appears as a ridge just oral to the tentacles, while flattening ensues, together with a progressive increase in the number of tentacles. Lithocysts are the last organs to appear, and then the medusae are set free from the parental cavities (Fig. 4, K).

In the second species, *Pegantha laevis* H. B. Bigelow (Fig. 4, L–N), Bigelow (1909) found a process of internal budding taking place from the endoderm of the peripheral canals, possibly from the ring canal alone. Only the endoderm is involved, and the proliferating ridges give off solid, ciliated, morula-like structures (Fig. 4, L–N). Whether they are liberated to develop independently, or whether they acquire some other host is not known.

Kramp (1947) found the larvae of *Pegantha clara* R. P. Bigelow (Fig. 4, A–E) to be floating parasites within the gastric cavity of *Periphylla periphylla* (Fig. 4, A). He distinguished two complexes of larvae in the youngest stages; one which differs in shape from the others he regarded as the primary larva, from which the others are produced by budding. When a bud attains a certain size, it becomes a free actinula with 2 and later 4 tentacles. A chain of actinula buds set free from the primary form may occur (Fig. 4, C); the actinula becomes medusoid by forming a circular collar just outside the tentacles. The medusae escape at about the time the mouth perforates.

The two remaining genera, the closely related *Cunina* and *Cunoctantha*, have been more widely studied. According to Bigelow (1909), internal budding similar to that of *Pegantha laevis* occurs in *Cunina peregrina* H. B. Bigelow (Fig. 5). In young individuals without gonads, ridges and thickenings develop on the oral surface of the gastric lobes. These are wholly of an endodermic nature, and proliferate to give off true buds. Buds at the time of constriction consist of about 24 cells and are set free into the parental gastric cavity (Fig. 5, A–C). Their later history is unknown but may be surmised in the light of what is known concerning other species of *Cunina*. In fact, Bigelow tentatively identified as *C. peregrina* a stolon found parasitically attached to the subumbrellar surface of a *Rhopalonema velatum*, together with some medusae recently detached from it. *Cunina* and *Cunoctantha* species are not self-parasitizing like *Pegantha*, but exploit other medusae, especially *Geryonia* and *Turritopsis*.

Cunina proboscidea Metschnikoff (Fig. 5, I–P) has been studied by Metschnikoff (1886), Woltereck (1905), Stschelkanowzew (1906), and by Hanitzsch (1921). According to Stschelkanowzew, there are three phases to the life cycle: the large, free-swimming, sexually mature *C. proboscidea* with 9 to 14 tentacles; a small 4-tentacled medusa, developed from an egg, attached to the stomach wall of the parent; and a budding stolon-like larva, either developed from an egg, attached to the stomach wall of the parent, or developed from the egg of the 4-tentacled medusa which becomes parasitic on *Geryonia*. Medusae asexually set free from the stolon become the large sexual *C. proboscidea*. The egg of the 4-tentacled parasitic medusa undergoes total and equal cleavage, associated with a nurse cell, to form a solid morula (Fig. 5, I–K). The endoderm is formed by delamination. Two pairs of tentacles are successively formed, after which the bell margin and velum grow out from the sides, and a mouth breaks through. The medusa is not set free, and with the subsequent growth of the gonads it degenerates into a mere sac.

Hanitzsch (1921) found the developmental cycle to be even more complex. He confirmed Metschnikoff that the egg is accompanied by a nurse cell. The egg may be fertilized, in which case it gives rise to a small γ male medusa. Or it may develop parthenogenetically into a so-called α-larva. This, while sexually immature, constricts off a series of buds from a central dorsal stolon (Fig. 5, M, N), then ceases to do so and continues to grow into a dwarfed female medusa. The buds formed in the process develop into β-larvae, each with a similar

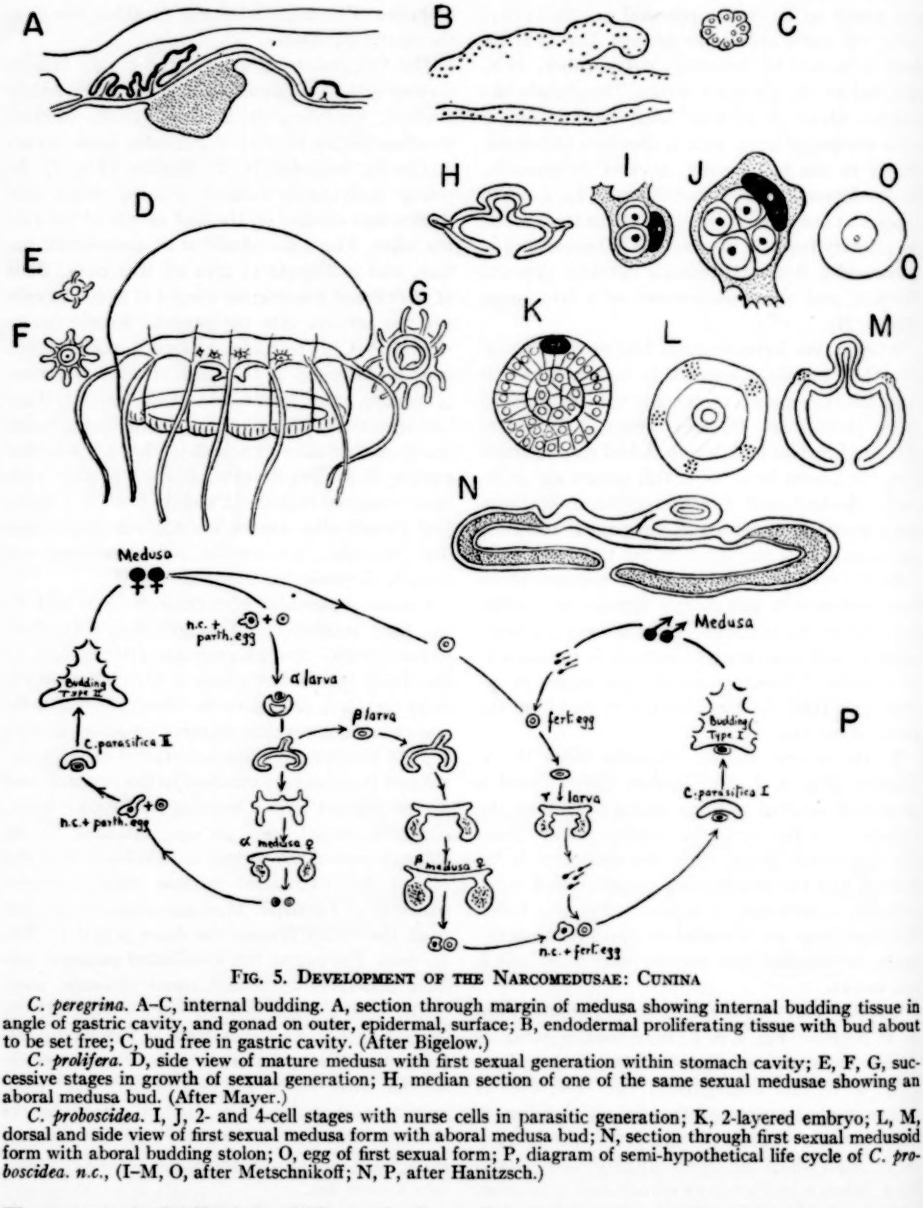
A
B
C
D
E
F
G
H
I
J
O
O
K
L
M
N
Medusa
n.c. + parth. egg
α larva
β larva
Budding Type II
C. parasitica II
n.c. + parth. egg
α medusa ♀
β medusa ♀
Medusa
fert. egg
γ larva
Budding Type I
C. parasitica I
n.c. + fert. egg
P

FIG. 5. DEVELOPMENT OF THE NARCOMEDUSAE: CUNINA

C. peregrina. A–C, internal budding. A, section through margin of medusa showing internal budding tissue in angle of gastric cavity, and gonad on outer, epidermal, surface; B, endodermal proliferating tissue with bud about to be set free; C, bud free in gastric cavity. (After Bigelow.)

C. prolifera. D, side view of mature medusa with first sexual generation within stomach cavity; E, F, G, successive stages in growth of sexual generation; H, median section of one of the same sexual medusae showing an aboral medusa bud. (After Mayer.)

C. proboscidea. I, J, 2- and 4-cell stages with nurse cells in parasitic generation; K, 2-layered embryo; L, M, dorsal and side view of first sexual medusa form with aboral medusa bud; N, section through first sexual medusoid form with aboral budding stolon; O, egg of first sexual form; P, diagram of semi-hypothetical life cycle of *C. proboscidea. n.c.*, (I–M, O, after Metschnikoff; N, P, after Hanitzsch.)

budding stolon, and then grow into dwarfed female medusae. Fertilized eggs from the products of dwarfed γ male medusae and β-female medusae yield budding stolon larvae of type I, the buds of which develop into large male medusae. Parthenogenetically developing eggs of dwarfed α-female medusae produce budding stolon larvae of type II, the buds of which form large female medusae. The cycle is shown diagrammatically in Fig. 5, P. The stolon larvae of types I and II are liberated from the parent forms and become parasitic within *Geryonia.*

Cunina prolifera Gegenbaur has a cycle essentially the same as that of *C. proboscidea* (Stschelkanowzew, 1906). The aboral buds produced by the medusae attached to the stomach wall of the parent host (Fig. 5, D–H) are formed in a pattern distinct from those of *C. proboscidea* (Hanitzsch, 1921).

Several species of *Cunoctantha* have been investigated (Fig. 6). The cycle of *Cunoctantha octonaria* Haeckel has been studied by Brooks (1886) and Wilson (1887). The earliest stages are unknown. A two-layered ciliated planula-like larva attaches itself by its mouth to the bell margin of *Turritopsis nutricula* McCrady. The cilia disappear and two pairs of tentacles appear successively at the aboral pole. The larva then enters the bell cavity of the host and clings to the wall of the subumbrella (Fig. 6, A). A long throat-tube is then developed and inserted into the mouth of *Turritopsis,* and the larva becomes therefore a parasitic actinula.

Other and similar larvae, which are budded off from the aboral pole between the tentacles, develop like the primary larvae (Fig. 6, B). They continue development, however, to become medusae. The bell or umbrella appears as four lobes between the four tentacles (Fig. 6, D), after which four new tentacles appear and the velum grows between the lobes.

According to Metschnikoff (1886), Mayer (1901), and Woltereck (1905), the cycle of *Cunina parasitica* Metschnikoff is essentially the same. *Geryonia proboscidalis* is parasitized in place of *Turritopsis,* while the parasitic budding larva gives rise to true medusa buds upon its sides. Each such bud is a simple evagination of ectoderm and endoderm. The mouth breaks through and then eight bell lappets and eight tentacles are formed simultaneously. Jelly is secreted by the endoderm, and eight radial stomach pouches are formed by local flattenings of the polyp-shaped buds.

Another narcomedusan larva, probably that of *Cunina lativentris* Gegenbaur has been reported by Damas (1936) to be parasitic in the cavity of parapodia of the pelagic polychaete *Tomopteris nisseri,* where it buds and increases enormously in number, until the host becomes castrated. Increase in number is first accomplished by a kind of polyembryonic fission of the morula (Fig. 6, M, N). Later, budding takes place at the aboral end of the actinula, and continues even after the medusoid condition has been reached (Fig. 6, R, S).

The cycle of *Cunoctantha fowleri* Browne is not fully known, but Browne and Fowler (1906) described medusa buds, *not* parasites, developing from the eight stomach pouches. Both the ectoderm and endoderm of each pouch contribute, and the buds project into the bell cavity. The mouth tube is formed before the tentacles and bell lappets. These buds were seen only in young nonsexual forms (Fig. 6, G).

The remaining narcomedusan whose cycle is known at least in part is the peculiar form *Polypodium hydriforme* (Fig. 3, O–R). It has been described at length by Lipin (1911). The budding stolon occurs as an internal parasite within the eggs of the sturgeon. Sturgeons on the spawning run in the Volga, opened before the eggs have been laid, usually are found with some eggs infected. Moreover, the condition of the hydroid indicates a considerable preceding history. Nothing whatever is known of the way in which the eggs become infected, nor is the sexually mature form of *Polypodium* known.

Within the sturgeon's egg the hydroid stolon is coiled spirally and is everted so that the endodermis is external and in contact with the surrounding yolk of the egg, while the epidermis faces inwards on to a closed cavity. Buds evolve as a series of bulges from the stolon outward into the yolk (Fig. 3, P). Tentacles grow inward from the epidermis into the central lumen, and each bud develops twelve tentacles. At the time of spawning of the sturgeon, the basal part of the stolon splits along its length, the whole becomes everted, including the attached polyps, so that epidermis and endodermis acquire their proper status (Fig. 3, Q). In the eversion process, each bud mechanically includes a mass of yolk in its basal region, and when the bud is set free from the egg and the stolon as a whole, it is consequently supplied with sturgeon yolk for continued growth. No mouth is formed, at least at this time. The liberated polyp

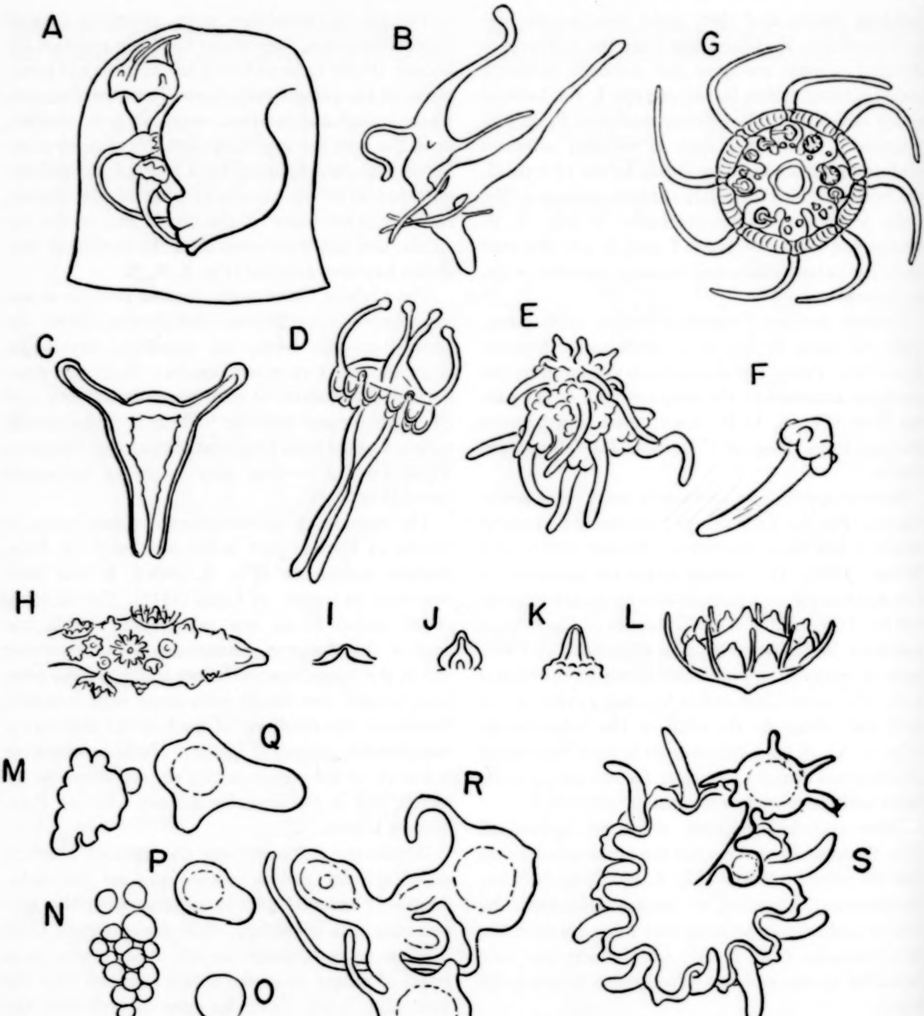

FIG. 6. DEVELOPMENT OF THE NARCOMEDUSAE: CUNOCTANTHA

C. octonaria. A, actinulae, attached to the manubrial lips of *Turritopsis nutricula;* B, budding of actinula; C, D, development of actinula into medusoid stage; E, F, stolon larva giving rise to numerous actinulae, and development of medusoid bell margin in actinula. (A–D,after Brooks; E, F, after Bigelow.)

Cunoctantha fowleri. G, medusa, showing medusae being budded from wall of gastric pouches. (After Browne.)

C. octonaria var. *kollikeri.* H, a stolon larva, probably of this form, budding medusae from its surface; I–L, stages in development of the medusa buds. (H–L, after Mayer.)

Cunina lativentris. M–R, budding and development within a parapodium of *Tomopteris;* M, N, proliferation of initial budding mass; O, P, Q, growth of actinula from individual bud; R, budding of actinula and onset of medusoid structure; S, budding of medusae from medusa. (M–S, after Damas.)

(Fig. 3, O) walks around on the river bottom by means of its tentacles (of which there are two kinds). Growth continues and is expressed in two ways. Tentacles increase in number to 24, while the polyp divides medianly to give rise to two individuals, each with 12 tentacles. The process continues until polyps with 12 tentacles are found dividing into two polyps each with 6 tentacles. These reconstitute polyps with 12 tentacles, and in fact several months after the sturgeon eggs are laid, free *Polypodium* polyps are to be found with 12 or 24 tentacles, and none with 6. It appears to be primarily a question whether or not a polyp first divides in a physical or organizational sense.

What is known of *Polypodium* is fantastic enough; what is left to be discovered cannot be less. Lipin (1926) has described free polyps with immature gonads (Fig. 3, R). These gonads are in themselves peculiar, being closed sacs with contained ovaries connected with the external base of the sac by an *oviduct*. The location of these sacs within the body of the *Polypodium* suggests that this is itself a modified medusa, and there may or may not be a better developed medusa included in the life cycle. Lipin attempted, not very convincingly, to show that *Polypodium* is a reduced type of the Coronatae among the Scyphomedusae.

II. ANTHOMEDUSAE AND LEPTOMEDUSAE

Among the Anthomedusae taken as a whole, though excluding the hydroid phases, medusa buds are produced at three sites, from tentacle bulbs, from the wall of the manubrium, and from the wall of the radial canals. Manubrial budding occurs in *Slabberia*, *Sarsia*, and *Eucodonium* among the Codonidae, and in *Podocoryne*, *Rathkea*, *Bougainvillia*, and *Cytaeis* among the Oceanidae. The production of medusa buds from the central regions of the radial canals may possibly be homologized with manubrial budding. Leaving this type aside, however, the conclusion seems inescapable that budding has been acquired on several occasions by this group of medusae.

In all cases, the production of buds is associated with a region of relatively high growth rate, that is, with a relatively elongating manubrium, as in *Sarsia* and *Slabberia*, or with regions of local growth, as in the case of tentacle bulbs, or with regions associated with the later production of gonads, as in the manubrial budding of the Oceanidae and from the radial canals in *Proboscidactyla*. In young juvenile forms, with a relatively high rate of growth in general, the presumptive gonadal tissues proliferate cell masses which develop into medusae asexually. As the general growth rate slows down, bud formation ceases and the gonads differentiate. The two processes may overlap somewhat in time, as in *Hybocodon*. Germ cells and bud rudiments do not always form from the same layer of tissue, but when they do, as in *Rathkea*, it is evidently a case of divergent differentiation from an essentially indifferent totipotent tissue.

The sequence of bud formation, often called the law of Chun, is primarily a matter of space becoming available for the initiation of buds in a progressive manner. A bud rudiment needs a certain minimum area available for its initial establishment. As such areas emerge in a budding region as a result of a general tissue growth, bud rudiments become successively initiated. In very small forms, such as *Podocoryne*, a girdle of three or four medusae develop around the manubrium, appearing successively in time (Fig. 8, A, B). In the larger medusae of *Bougainvillia*, between twenty and thirty may be developing at the same time (Fig. 8, E), although each medusa bud of a certain stage is approximately the same size as similar stages in *Podocoryne*. In the much larger medusa of *Cytaeis* (Fig. 8, I), the individual medusa bud, for a given stage, is no larger, but over a hundred buds may be developing at one time from the extensive manubrial surface. The tendency for buds to develop along a helical line on the manubrium is mainly due to progressive distal growth of the manubrium and the successive manner in which available areas for bud initiation become delimited around the manubrial circumference.

The type of budding exhibited by *Niobia* (Fig. 9) involves phenomena of a more subtle nature. While in this case budding is essentially a tentacle bulb activity, it is mainly a growth of the whole bulb and its progressive development of an independent medusoid organization, as its progressively increasing size permits. This developmental or reconstitutional reaction to local growth comes within the category of C. M. Child's "physiological isolation," but it does not enlighten that enigmatical phrase.

It is also significant that budding in these anthomedusan medusae is primarily an activity of juvenile forms still in relatively rapid growth, and that in *Niobia* as in others, sexual maturity succeeds the budding and growth phase. It is also of particular interest that when budding does extend through into the sexually mature phase, as in *Hybocodon*, the buds exhibit a sexual maturity comparable with that of the parent form, suggesting a possible correlation of gonad differentiation with a specific growth rate in the double parent-bud organism (Fig. 7, O).

In two of the largest families of the Leptomedusae, namely, the Plumulariidae and Sertulariidae, free medusae no longer exist, and the gonophores are reduced to sessile sporosacs. Free medusae are produced within the Campanulinidae and the Campanulariidae, although in both of these families reduction of the gonophores to sporosacs has also occurred in a number of cases. Within this order, the production of medusa buds by the free medusae is accordingly relatively rare, but the few known cases are of considerable interest, especially when we compare the production of medusae by medusae with the production of similar medusae by the respective hydroids.

In the Campanulinidae, medusae develop from the hydroid as terminal developments from independent outgrowths, for example, in *Campanulina* (Fig. 10, F), much as in the Anthomedusae. Medusa buds formed by a free medusa, as in *Euchilota* (Fig. 10, G), develop as direct outgrowths in a comparable manner. In this case they form from the outer wall of the radial canals, somewhat as in the anthomedusan *Proboscidactyla*, coinciding in position, though not in time, with the gonadal region. Gonads differentiate after budding has ceased.

Among the Campanulariidae the case of *Phialidium mccradyi* is outstanding. Medusa buds are produced in large numbers by the free medusa, as well as by the fixed hydroid. The significant fact is that, whether hydroid or medusa, medusa buds are formed in only one way, as outgrowths of the blastostyle of a gonangium. This is the method which is universal within the family, by which the hydroids produce medusae. In the only free medusa known to produce medusa buds, the procedure is identical. It is also notable that the gonangia formed by the medusa are produced at the site of the gonads, but at an earlier phase preceding sexual differentiation.

The third case, *Gastroblasta*, probably also a campanularian, raises the same general problem as *Niobia*, why an organism which continues to grow more along one axis than another should reconstitute itself into two similar organisms.

Anthomedusae

The Anthomedusae (-Gymnoblastea) are reviewed here primarily as medusae capable of budding off other medusae asexually. The diversity of reproductive behavior among the hydroid phase of the various forms is too great to be encompassed in the present account, and merits separate discussion. Medusa budding is described below under the heading of major families, in order to emphasize the polyphyletic nature of the process. Of those included, the genera *Sarsia* (-*Syncoryne*), *Hybocodon*, *Eucodonium*, *Slabberia*, *Margelopsis*, and *Pelagohydra* all belong to the family Codonidae. *Podocoryne*, *Cytaeis*, *Bougainvillia*, *Rathkea* (-*Lizzia*), *Proboscidactyla*, and *Niobia* belong to the Oceanidae. *Cladonema* and *Eleutheria* are members of the Cladonemidae.

Codonidae

The genus *Sarsia* is one of the more interesting, for among its species it includes a number which do not produce buds at all, one that produces medusa buds in series from the base of each of its four tentacles (*Sarsia prolifera*, Fig. 7, A), and one that produces medusa buds along the length of an elongating manubrium (*Sarsia gemmifera*, Fig. 7, B, C). Thus one species of *Sarsia* produces manubrial buds in a manner strictly comparable with *Slabberia catenata* (Fig. 7, E, F), and another with the type of budding from the base of the tentacle characteristic of *Hybocodon prolifer* (Fig. 7, I). *Eucodonium*, on the other hand, develops medusa buds from a manubrium in a way more like that of the Oceanidae (Fig. 7, H).

Both *Sarsia gemmifera* Forbes and *Slabberia catenata* Forbes and Goodsir have been investigated by Chun (1896), and in spite of the adult medusae being assigned to separate genera they exhibit a remarkable similarity in the manner of budding. Inasmuch as the hydroid of *Slabberia catenata* is, like those of *Sarsia*, a *Syncoryne*, the relationship may actually be a very close one. A hydroid of *Syncoryne eximia* (Fig. 7, D) is given as an illus-

(Fig. 7—*Continued*)

S. catenata. G, non-budding individual with manubrial gonad. (After Mayer.)

Eucodonium brownei. H, manubrial medusa buds. (After Mayer.)

Hybocodon prolifer. I, medusa buds developing from single, divided tentacle base and from tentacle base of advanced bud. (After Mayer.) O, Sexually mature medusa producing mature bud. (After Hartlaub.) P, assymmetrical growth and budding of tentacle bulb. (After Brooks.)

Margelopsis haeckelii. J, K, actinulae growing from manubrium, and free, pelagic, actinula of same with medusa buds between tentacle rings. (After Hartlaub.)

Coryne tubulosa. L, hydroid budding off a free hydranth; M, a free pelagic hydranth with young medusa bud. (After Rees.)

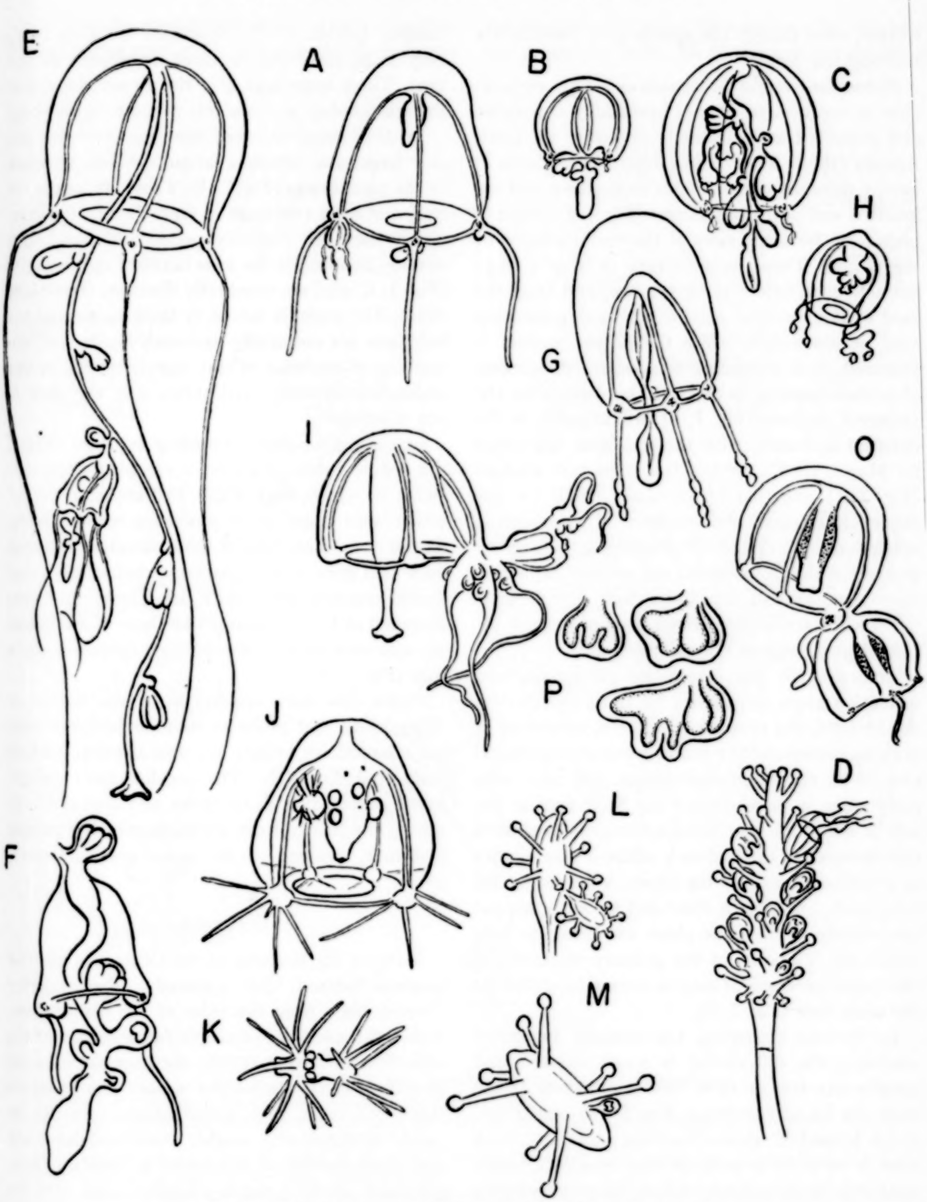

FIG. 7. BUDDING IN THE ANTHOMEDUSAE, FAMILY CODONIDAE

Sarsia prolifera. A, medusa buds forming from base of tentacles. (After Mayer.)

Sarsia gemmifera. B, C, young medusa with medusa buds developing from an extending manubrium. (After Chun.)

Sarsia (= *Syncoryne*) *eximia.* D, hydroid, with medusae forming between the tentacles. (After Allman.)

Slabberia catenata. E, long manubrium bearing medusa buds; F, advanced medusa bud of same bearing younger bud on stalk and series of buds on its own manubrium. (After Chun.)

(*Continued on p. 306*)

tration, even though the species as a medusa is a non-budding form.

Hybocodon prolifer L. Agassiz is a form remarkable in many ways. It was beautifully illustrated and described as a dynamic organism by Louis Agassiz (1862). The medusa differs from *Sarsia* in having three out of four tentacles abortive, and the fourth a well developed cluster (Fig. 7, I). Medusa buds form from the sides of the tentacle bulbs of the cluster. These buds in turn develop a large tentacle even before being set free, and from the base of this, medusa buds of the next generation may be discernible before the parent medusa is liberated. It is interesting to compare the process of medusa-budding as described by Agassiz for the youngest medusae (Fig. 7, P), still attached to the parental hydranth, with the condition illustrated by Mayer (1910) for the free miniature medusa (Fig. 7, I), and that by Hartlaub (1933) for medusae already showing evidence of approaching sexual maturity (Fig. 7, O). Perkins had earlier reported simultaneous sexual and asexual reproduction, medusae still developing from the tentacle bulbs while actinulae, derived from eggs, grew attached to the side of the manubrium.

According to the description of medusa-bud formation given by Agassiz for those attached to the hydroid, the primary outgrowth, consisting of both endoderm and ectoderm, grows at an unequal rate in its two transverse planes, and at a very early stage in development the body wall at the side of one of the four radial tubes grows out until the diameter of the bud as a whole is about twice as great in one axis as the other. A second lateral outgrowth, and then a third and a fourth, appear successively in the same plane and direction long before the liberation of the primary medusae, so that many generations may be seen in formation at the same time (Fig. 7, P).

In the free-swimming but sexually immature medusae, the differential is much reduced and usually but two or three bud generations at the most are found coexisting. Finally, as sexual maturity is reached, asexual budding may cease, or at least is reduced in rate, so that usually a single relatively large medusa bud is found developing from the tentacle base. In such cases, even the bud itself may show evidence of sexual maturity, and it seems likely that the last bud to be liberated may pass directly into a condition of sexual maturity without exhibiting either a preliminary or coexisting phase of asexual reproduction. While the exact size of *Hybocodon* eggs has not been recorded, Uchida (1927) described them as being very large, only two or three developing at one time. These large eggs give rise to actinulae, and the relationship to *Tubularia* is again emphasized.

In *Margelopsis haeckeli* the eggs are also few and large, and actinula larvae develop attached to the manubrium (Fig. 7, J). These are finally set free, and have two rings of tentacles. In this condition they are typically pelagic. Medusa buds develop as a ring in the zone between the tentacles (Fig. 7, K) and are eventually liberated (Hartlaub, 1933). The actinula larvae in these forms and tubularians are essentially hydranth heads, and the budding of medusae in this case is typical of the budding from sessile hydranths, only the stalk is not developed.

In *Coryne tubulosa*, according to Rees (1941), the sessile colony may be a creeping form, the stems of which bear single hydranths, many of which were found to be producing medusa buds. At the same time some of the hydranths produced buds that grew to form hydranth rather than medusoid organization (Fig. 7, L). These buds were liberated as free hydranths like those of *Margelopsis*, and were capable of producing medusa buds in turn (Fig. 7, M).

Climacodon ikarii appears to be also similar to *Margelopsis*, and produces stemless hydroids that are adapted for pelagic life and develop medusa buds (Uchida, 1927). The peculiar form *Pelagohydra mirabilis*, with tentacles and medusa buds arising irregularly from the surface of the pelagic hydranth, belongs to the same group (Dendy, 1913).

Oceanidae

Many of the medusae of the Oceanidae likewise produce medusa buds asexually. The majority develop buds from the sides of the manubrium. This is the case for *Podocoryne fulgurans*, in which, according to Mayer (1910), they appear in series in a close helix. *Podocoryne minuta* also produces manubrial buds, and Mayer states them to be purely of ectodermal origin. Manubrial buds are also characteristic of *Bougainvillia frondosa*, *Bougainvillia niobe*, *Cytaeis atlantica*, and *Rathkea octopunctata* (Fig. 8, A–I). The helical arrangement of the budding series is again evident in *Rathkea* and was emphasized for this form by Chun (1896). He also demonstrated that both the ectoderm and endoderm of the buds are of manubrial ectodermal origin. It may be seen from Fig. 8, D, E, and I, that the number of buds developing at the same time from the manubrium of the three forms illustrated varies greatly. If, however, the three figures were shown at the same scale, it would be seen that the young buds were of much the same size and that the variable is in the size of the budding manubrium; the larger the budding area, the more numerous the buds. All of the forms recorded as producing medusa buds asexually are comparatively small and miniature, and the attainment of sexual maturity occurs some time after the cessa-

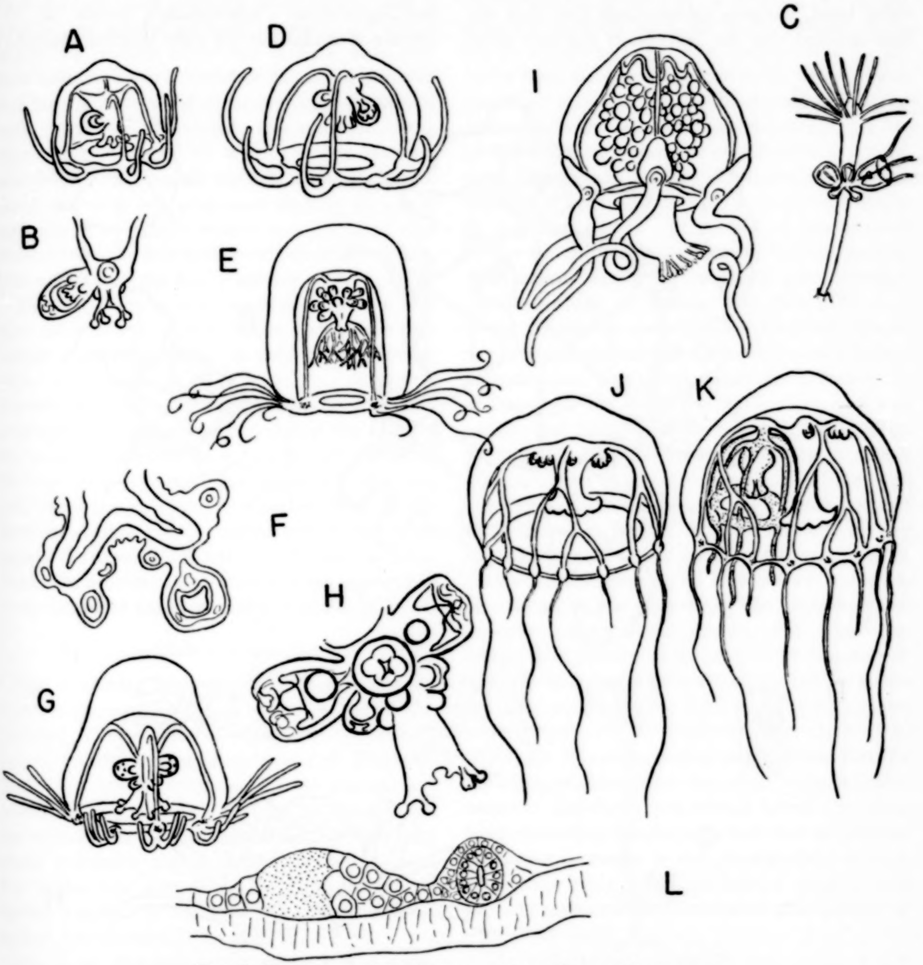

Fig. 8. Budding in the Anthomedusae, Family Oceanidae

Budding of medusae from the manubrium or the radial canals.

Podocoryne fulgans. A, young medusa; B, enlarged view of manubrium. (After Mayer.)

Podocoryne cornea. C, hydroid. (After Hincks.)

Bougainvillia frondosa and B. niobe. D, E, with manubrial buds; F, section through manubrium of *B. niobe* to show ectodermal origin of the buds. (After Mayer.)

Rathkea octopunctata. G, medusa; H, manubrium showing spiral sequence of buds. (G, after Mayer; H, Chun.)

Cytaeis atlantica. I, with very numerous manubrial buds. (After Haeckel.)

Proboscidactyla ornata var. *gemmifera.* J, K, multiple medusa buds arising at junction of the 4 radial canals with the stomach wall. (After Mayer.)

tion of budding. The gonads also develop from the manubrium.

Proboscidactyla ornata var. *gemmifera*, on the other hand, produces medusa buds from four stolons situated near the junction of the four radial canals with the stomach (Fig. 8, J), and the medusae develop suspended within the subumbrella (Fig. 8, K). According to Mayer (1910), these forms are typical of medusae from South Carolina southward. In cooler waters to the north, the sexually mature form may possibly be produced without passing through a juvenile budding phase. In any case, the gonads develop at the site of the budding stolons. *Proboscidactyla ornata* var. *stolonifera* is similar but has eight budding stolons at the second and third forkings of the radial canals, instead of four (Bigelow, 1909).

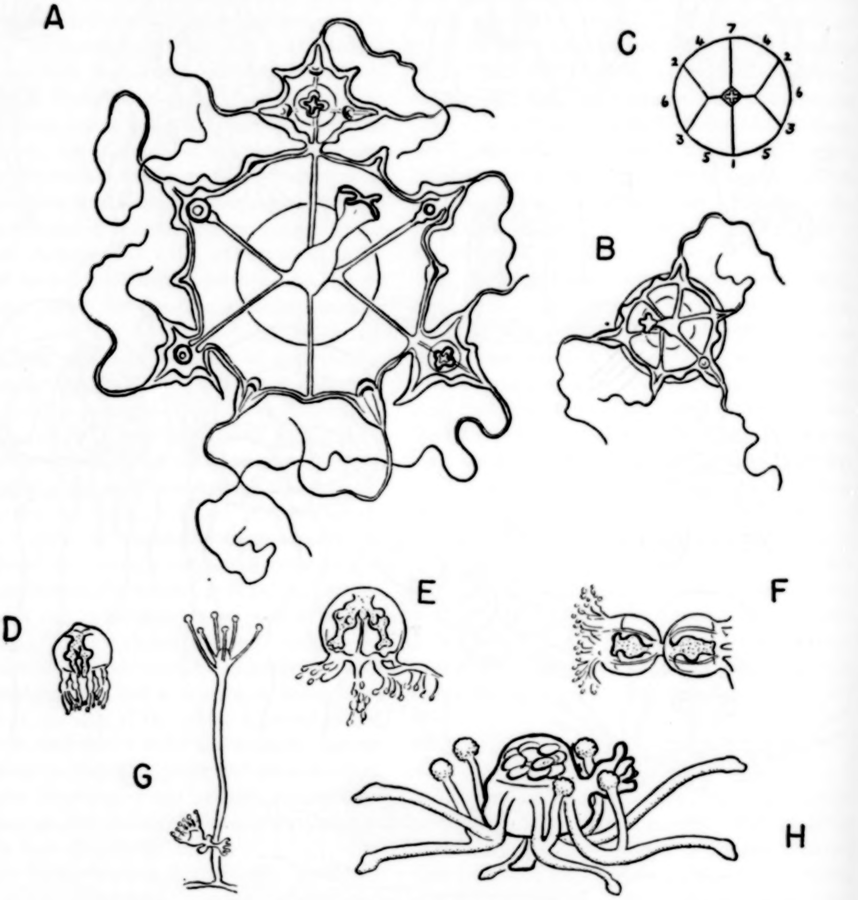

FIG. 9. BUDDING IN THE ANTHOMEDUSAE

Niobia dendrotentaculata. A, medusa with tentacle bases transforming into medusae; B, newly-liberated medusa bud; C, diagram showing order of development and liberation. (After Mayer.)

Cladonema radiatum. D, E, F, three stages in process of division of manubrium and bell. (After Pasteels.)

Clavatella prolifera (= *Eleutheria dichotoma*). G, hydroid budding medusae; H, mature medusa in creeping position, with eggs in dorsal brood sac, and medusa bud forming from side of bell. (G, after Hincks; H, after Hartlaub.)

One of the most fantastic forms of asexual reproduction among medusae is that of *Niobia dendrotentaculata*, as described by Mayer (1901, 1910).

There are twelve tentacles, of varying age, and bilaterally symmetrical in arrangement (Fig. 9, A). Each tentacle bulb develops progressively into a medusa, the original tentacle becoming the oldest or primary tentacle of the new medusa. Each tentacle bulb develops in order of its age, at first one and then in pairs until all twelve original tentacle bulbs have been liberated as free medusae of the type shown in Fig. 9, B. When this has been accomplished, the residual medusa no longer reproduces asexually but progresses directly to sexual maturity. The gonads mature and the large eggs develop from the interradial surfaces of the surface, from which they are finally set free.

The first stage in the transformation of a tentacle bulb into a medusa is the appearance of a hollow outgrowth upon the floor of the subumbrella close to the tentacle bulb. This outgrowth consists of both ectoderm and endoderm. It shortly develops two pointed outgrowths on the sides of the tentacle bulb and these become new tentacles. As they grow, a younger pair appears farther out, and these are followed by another (Fig. 9, A). Even before the young medusa breaks free of its parent, the base of its oldest tentacle has started to repeat the process. The sequence of the appearance of the marginal medusae is shown in Fig. 9, C.

Cladonemidae

Two remaining medusae among those that commonly reproduce asexually belong to the Cladonemidae. The medusa of *Cladonema radiatum* is known to divide completely into two (Pasteels, 1939). The division commences in the manubrium, passing from the mouth towards its base. When the manubrium is thus duplicated, the bell as a whole gradually elongates and constricts, until just before final separation, two medusae are attached together by the apex of their exumbrellar surface, like siamese twins (Fig. 9, D–F).

Eleutheria dichotoma Quatrefages is a peculiar medusa produced by the hydroid *Clavatella prolifera* Hincks (Fig. 9, G, H). According to Hartlaub (1907), the eggs develop in an ectodermal brood pouch connected with the bell cavity by six interradial openings. Medusa buds develop upon the exumbrellar side of the ring canal, usually occurring at the same time as sexual reproduction.

Leptomedusae

In many ways the Leptomedusae are the most specialized of the four groups, particularly in the case of the hydroid phase. There is a general tendency for the medusa stage to be either limited in its elaboration or even to be reduced or omitted from the life cycle. As in the Anthomedusae, there are no known cases where a medusa develops directly from the egg. Eggs invariably develop into planulae, and the endoderm of the planula is formed either by unipolar ingression or by a multiple ingression or infiltration of cells from the outer layer. Apparently neither invagination nor delamination occur. Many studies have been made of the development and growth of the hydroid phases of the Leptomedusae s. Calyptoblastea, and cannot readily be reviewed here. Brooks' (1886) account of ***Eutima mira*** McCrady does however illustrate several points of interest. Cleavage results in this case in the formation of a hollow blastula, after which cells apparently slide inwards at numerous places and eventually form an inner endodermal lining enclosing a gastric cavity (Fig. 10, A, B, C). Mayer's statement (1910, p. 298) that the endoderm forms by delamination from the inner ends of the blastula cells is a conclusion not to be found in Brooks' original account. In any case, the planula so formed develops a purely ectodermal invagination at its narrow end, a feature also found in the planula of the anthomedusan ***Turritopsis nutricula*** (cf. Brooks, 1886). This ectodermal invagination disappears after attachment of the planula; and finally attachment of the stolon produced by the planula is by means of the general adhesive property of freshly secreted chitin (Fig. 10, D, E). The invagination recalls rather forcibly the adhesive attachment disc of the young scyphistomae of ***Haliclystus*** and related forms. The other feature noted by Brooks is the fact that the planula of ***Eutima*** increases in size considerably, in fact, even while it is a still single-layered blastula, and he was convinced that it possesses some method of nourishing itself.

The calyptoblast hydroids that produce free medusae may be roughly divided into campanulinids and campanulariids, the former producing medusa buds singly from erect or creeping stolons (e.g., *Campanulina acuminata*, Fig. 10, F), the latter from the lateral wall of specialized blastostyles, as in *Obelia*. Only in one known case, however, are medusae described which bud new medusae directly from the old. This is *Eucheilota paradoxica* Mayer (Fig. 10, G, H). In the young medusae the gonadial regions are situated close to the manubrium, but with further growth they ex-

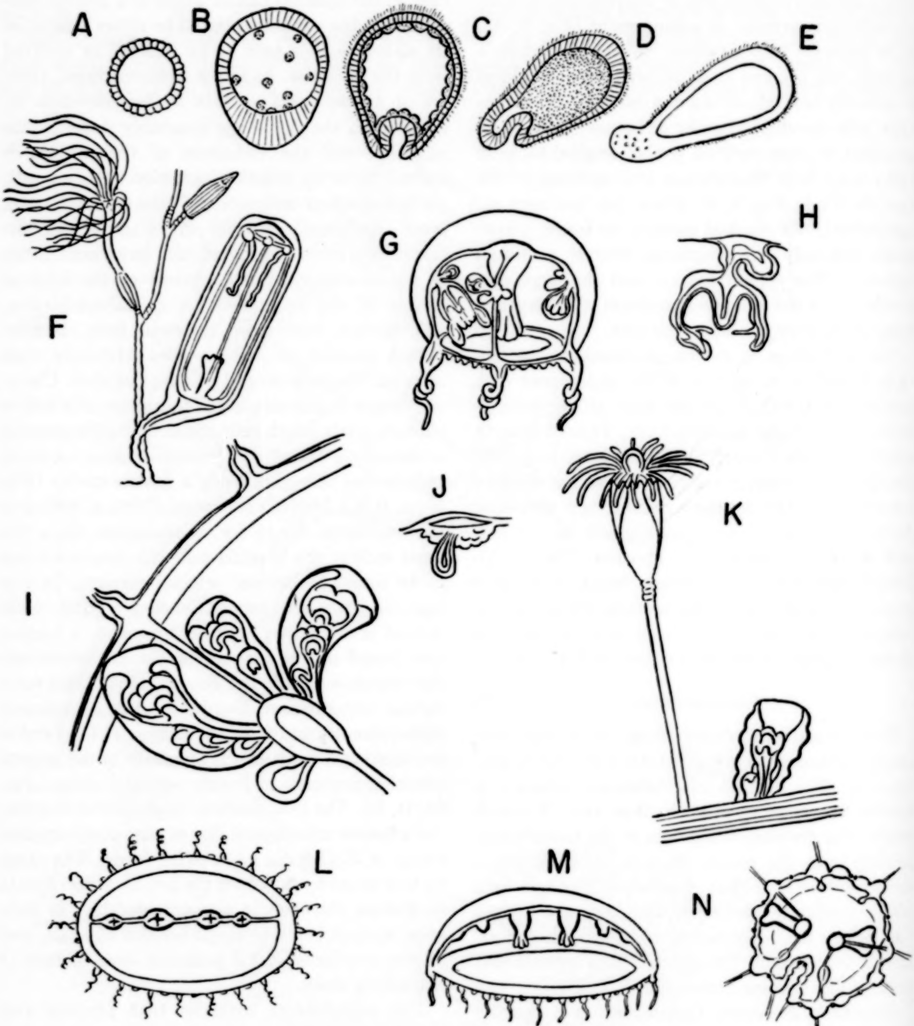

Fig. 10. Development and Budding in the Leptomedusae

Eutima variabilis. A–E, development of the egg. A, blastula; B, infiltration of endoderm; C, D, young planulae with proximal ectodermal sucker; E, later planula with adhesive chitin replacing sucker region. (After Brooks.)

Campanulina acuminata. F, hydroid and medusa bud. (After Hincks.)

Eucheilota paradoxica. G, H, medusa buds forming from radial canal site, and section of a budding unit and gonad site. (After Mayer.)

Phialidium mccradyi. I, bell margin and radial canal, showing development of medusa buds from blastostyles in gonangia; J, side view of young gonad and a blastostyle; K, hydroid and upper region of a gonangium attached to alga. (I, K, after Brooks; J, after Mayer.)

Gastroblasta ovalis. L, M, ventral and side view, showing multiple manubria and elongation of medusa prior to transverse division. (After Mayer.)

tend along the radial canals. Medusa buds arise from the site of the gonads before gonadal histogenesis commences, and the medusae develop suspended within the cavity of the subumbrella. According to Mayer (1910, p. 255), both endoderm and ectoderm are involved in the outgrowths, and a succession of medusae arise from a single initial proliferation (Fig. 10, H).

Phialidium mccradyi (Brooks) (Fig. 10, I–K) is clearly a campanularian and the only one known in which the medusa buds medusae. It has been studied by Brooks (1887), Sigerfoos (1893), and Mayer (1910). Gonads may develop directly on the radial canals, or, more usually, outgrowths may form from the presumptive gonadal tissue. According to Sigerfoos, the single layer of small ectodermal cells thickens and become multilayered. The outer ectodermal layer becomes separated from the rest by a supporting lamella. The endodermal layer then evaginates into the thick middle layer of ectodermal origin, and at the same time loses its connection with the endodermal lining of the presumptive gonad. Thus cylindrical tubes of endoderm come to lie within the mass of ectoderm, and the blastostyles so formed can receive no food directly from the medusa stomach and the canal system. In effect they are tissue parasites. Typical blastostyles and gonangia are formed, complete with gonothecae, and the medusa buds are formed from the lateral wall of the blastostyle. Brooks also described the hydroid (Fig. 10, K), which appears to be a typical species of *Clytia*, and forms gonangia also characteristic of this genus. It is notable that medusae apparently can be produced by one method only, via the campanularian blastostyle, although the blastostyle itself may be produced either from a creeping hydroid stolon or from the gonadal site on the radial canals of the medusa.

The remaining leptomedusan to be considered here is the peculiar *Gastroblasta raffaeli* Lang (Fig. 10, L–N). Its hydroid phase is unknown. The medusa is characterized by having more than one stomach, a consequence apparently of growth occurring relatively more along one transverse axis than the other. This medusa reproduces itself by fission, a process described in considerable detail by Lang (1886). The bell margin grows inwards, the plane of division being at right angles to the long axis of the ellipse, and passes between the oldest and the next oldest manubrium. When about to divide, the oldest lithocyst divides into two and the marginal cleft passes between the products, until the medusa is cut completely into two halves (Fig. 10, N). Each part then develops new canals, manubria, and tentacles, until the original form is restored and the cycle renewed. A related form is illustrated by Mayer, *Gastroblasta ovalis* (Fig. 10, L, M), in which one canal passes the length of the ellipse and bears six or more manubria at one time. Reproduction by fission is probable, but is not certainly known.

GENERAL DISCUSSION

In general, the eggs of the Hydromedusae exhibit the same variability in size as those of the Scyphomedusae. Both groups contain species with large eggs that develop directly into medusae, both have forms with eggs of moderate size that develop into sessile hydroids, and in both cases there are some with minute eggs that grow and produce buds in rapid succession before any kind of functional organization becomes apparent.

Cleavage of the eggs in both groups is regular and without obvious pattern, but in *Haliclystus*, *Lucernaria*, and *Chrysaora* among the Scyphomedusae, and in *Eutima* and *Turritopsis* among the Hydromedusae, the blastula and early planula stages undergo very considerable growth, far beyond the potentiality of internal reserves. Wietrzykowski (1912), Teissier (1929), and Brooks (1886), respectively, insist on the existence of some means of external nourishment. There is little or no evidence that it is obtained by the blastomeres in a particulate form. It is possible, even probable, that the nutrient material necessary for this growth consists of the organic solutes usually present in some degree in seawater (Keys, Christensen, and Krogh, 1935), especially in coastal waters. The development in the Narcomedusae of medusae from minute eggs or buds within the gastric cavities of the parent or of some other medusa shows that the capacity to exploit such resources is undoubtedly present.

Excluding the vagaries of the life-cycles, there appear to be three principal ways in which a medusa may be formed. Medusae may develop in a rather simple and direct manner, as in the scyphomedusan *Pelagia* and occasionally in *Aurelia*, and in the trachymedusan *Liriope* and *Geryonia*. There are differences between the two groups, but the outstanding feature of the development is the growth and expansion of the embryo in the equatorial plane. An equally definite though very different procedure, namely, through the formation of an entocodon, occurs in the development of medusa buds in the Anthomedusae and Leptomedusae as a whole, and in *Gonionemus*, *Craspedacusta*, and *Limnocnida* among the Trachymedusae. In all of these the egg develops into a planula, and becomes a hydroid which produces medusa buds directly or indirectly. The development of a planula, in contrast to the direct development of a medusa from the egg, is associated with a marked polar organization and growth of the cleaving egg. The third method whereby medusae are produced involves the formation of an actinula. This stage consists of an elongated body with a ring of tentacles at the oral end. In most cases where it has been described or discussed, the reference has been to larvae free in the water, but the morphological stage is recognizable in some of the parasitic stolon larvae of certain Narcomedusae, and in the young scyphistoma of the Scyphomedusae.

The question arises what the actinula really does constitute, and the answer depends a great deal upon the context, for it can be interpreted in terms of procedures of development or in terms of phylogenetic relationships. Various opinions have been expressed concerning the evolutionary origins of medusae with the actinula and hydroid phases in mind. Bohm (1874) suggested that medusae evolved in the first place from floating forms of some kind. Claus (1882) also considered the medusae to be primary, and the hydroid a medusa larva. Mayer (1910) considered the anthomedusan, narcomedusan, and scyphomedusan types, at least, to have evolved independently. This view has some plausibility, but it has been carried to naive extremes by Fraser (1946) who regarded all sporosacs and abortive or sessile medusoid forms among the Anthomedusae and Leptomedusae to be medusae in process of independent, possibly arrested, evolution into free medusae. This is essentially a return to an older concept, the implications of which have apparently at no time been fully considered, namely, that the hydroid is the primitive form and that the medusa has originated as a gradual specialization of the reproductive members of a polymorphic hydroid stock. In recent times Uchida (1927) also has expressed this point of view.

Brooks (1886) adopted a compromise interpretation after an intensive study of the actinula larvae of the Narcomedusae. His hypothesis, strongly influenced by the theory of recapitulation dominant at the time, was that the actinula represents a primitive type of coelenterate from which the medusae have continued to evolve as free-swimming sexually mature organisms, and from which on the other hand the sessile hydroid organisms have arisen with subsequent elaboration of the processes of asexual reproduction. This viewpoint has its attractions, and it may be that the development of an actinula does represent the conservative, old-fashioned type of development of medusae. Even in such a case, however, it does not follow that the actinula was ever an adult form. A surer approach is to regard the actinula as the expression of a certain developmental situation.

Possibly the development of *Aurelia* gives the key to the problem. According to Haeckel (1880) the smaller eggs of *Aurelia* developed into planula larvae which attached and became scyphistomae, giving rise to young medusae by strobilation. The largest eggs developed, like those of similar size of *Pelagia*, into medusae directly. Eggs not quite so large became elongated larvae, as though becoming typical planulae, but continued to form tentacles and a mouth at one end while still in the free-swimming stage—in other words, became a typical actinulae. Subsequent development evolved the medusa organization by direct transformation, without involving a sessile phase. Accordingly, an actinula is formed as a stage in the development of a medusa egg when the size and polarity of the larva are of a certain rather critical value.

In all orders and classes of medusae there is a general tendency for the sessile hydroid stage, when such exists, to reproduce during its earlier phases of growth by means of asexually produced buds. In the Trachymedusae, Narcomedusae, and Scyphomedusae they are formed laterally from the body wall of the polyp and set free. In the Anthomedusae and Leptomedusae, the branching basal or erect growths are more or less comparable, at least in relation to the maintenance and augmentation of the medusa community. In any case the phenomenon is essentially one associated with the relatively rapid general growth of young stages in the life cycles, whether it is the 'frustules' of *Gonionemus*, *Craspedacusta*, or *Haliclystus*, or the budding of parasitic actinulae or the asexual "polyembryonal" budding of Narcomedusae, or the formation of lateral buds by scyphistomae of *Cyanea* (Berrill, 1949) or *Cassiopea* (Bigelow, 1900). The formation of outgrowths destined to become medusae rather than other structures is associated with growth in a transverse plane and a relatively slow polar or terminal growth rate, not only in the Trachymedusae but in hydroids in general (Berrill, 1949a).

Leaving aside the various ways in which medusae are produced by hydroids proper, the diversity of locations from which they are budded off from other medusae definitely indicates a multiple origin of this particular activity. Production of medusa buds from the surface of the tentacle bulbs, manubrium, radial canals, ring canal, and the aboral pole of the medusa, cannot be homologized more than as an exploitation of a general capacity for reconstitution and an ability of some sort to isolate regions from the innate wholeness of the individual.

When a comparison is made of the actual origin or initiation of buds produced by medusae, whether they develop into medusae directly or not, it is clear that both the unspecialized epidermis and endodermis are basically totipotent and capable of giving rise either to the whole organism or at least a large part of it. A comparison of the origin of gonads confirms this conclusion (Liu and Berrill, 1948).

In a general way, growth, budding, and sexual maturation appear to be closely related. In all orders the production of medusa buds takes place in small immature medusae. As the growth rate slows and adult size is approached, budding usually ceases and sexual differentiation ensues.

Lastly, relative growth in young medusae may result in simple or modified fission, as in *Gastroblasta*, *Cladonema*, *Niobia*, and *Polypodium*, but as implied earlier, this is a phenomenon an understanding of which would illuminate the nature of organism itself and is beyond the scope of the present discussion.

SUMMARY

1. The Hydromedusae is a heterogeneous group, the four orders of which may represent a considerable extent of parallel evolution.

2. Direct development of eggs into medusae without passing through sessile hydroid stage occurs only in the orders Trachymedusae and Narcomedusae. As in the class Scyphomedusae, there is a correlation between type of development and size and degree of polar organization of the egg.

3. Asexual reproduction, by a process of budding, may occur at almost any stage of the life cycle. It may be a form of polyembryony, a fragmentation of the cleaving egg or of a young bud. Buds or new medusae may form from an aboral stolon of a young medusa, or lateral outgrowths of a polyp. They may arise from the outer margin of a medusa or from the inner lining of the ring canal. They may also arise from tentacle bulbs, from the outer surface of radial canals, or from the outer wall of the manubrium. They may be formed by actual division or partition of the medusa as a whole.

4. The production of buds is associated with young and juvenile stages, and with the absence of gonads. Sexual maturity and even young gonads are in general associated with a cessation of budding.

5. Buds that develop into sexually mature medusae can arise from epidermis alone, endodermis alone, or from a combination of both kinds of tissues. Each type is accordingly totipotent.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

SCIENCE IS A SACRED COW.

By Anthony Standen. E. P. Dutton & Co., New York. $2.75. 221 pp. 1950.

> "The Long Island Rail Road afforded me plenty of time for writing this book. The more the train was delayed, the more time I had to write."—Acknowledgment by the Author.

Here is another in the long list of harangues against science. Generally they are written by metaphysicans who are given to worrying whether Science Can Save Us and If Not, Why Not? Occasionally one by a practicing scientist (usually with hygienic tendencies) will find an agreeable publisher. Of late, when some of the latter sound off they are full of self-condemnation and rather incoherently develop the theme, *Oh, my! What have I done?* But even such authors develop similar general ideas or, if they vary them, it is but slightly. The treatise under consideration is not very different. In fact, it might be said that other authors of similar essays have possessed greater gifts of literary utterance. This volume is principally concerned with the immorality of science and scientists, and citizens are warned to be very careful or they will have a bunch of scientific tyrants running amok and injecting the unwary with truth serum and then turning them over to "the most alarming scientist . . . the social scientist." This low fellow will then complete the nefarious business with that "typical instrument of the social scientist . . . the straw poll."

However, this book is unique in one respect: the town of Hauppauge, Long Island (the author's residence) and the Long Island Rail Road are brought in. A critical examination of the data does not warrant the conclusion that the L.I.R.R. is to be blamed for this volume, granted it is so terrible and unpredictable a railroad that even the Pennsylvania R.R. had to give it up. True, it is reported that only the strong of mind and stomach ought to hazard riding on it with any regularity. Nevertheless, the responsibility for this latest caveat against science and scientists must rest elsewhere. Scapegoats are to be avoided even when they take the form of such obvious public enemies as the L.I.R.R. There also appears little likelihood that the blame is due to the stark reality of life in Hauppauge, Long Island, for some truly first rate essays have come out of even such places as Baltimore.

> "One of the marvelous discoveries of Science is 'brain waves.' They are detected by an electrical device strapped over the head. They are very useful in diagnosing epilepsy, and they are intensively studied by scientists, trying to find out what happens inside the mind. Up to the present, scientists have not tried to regulate these brain waves, or to change them. If ever they do, we must keep a sharp eye on them. For since, as we saw before, science can tell us nothing about what is good or bad, and since scientists have

> not been trained to think any other way than scientifically, they have nothing but their own half-baked ideas to go on in deciding *whose* brain waves are to be changed, and what to change them to" (p. 203).

No one with any depth of perception will dispute the fact that there are and probably always will be quacks and other odd fish who, by their own representation, pass themselves off as scientists. Such fakers and scientific moralists can be seen in and about the ranks of science. They are easily recognizable even by the majority of college sophomores. Generally they are considered nuisances not to be taken seriously. When they occupy high places, as occurs all too frequently, they are more painful nuisances, but still only nuisances. That Standen has not been able to recognize them and is alarmed by them and their idiotic bombast simply means that he has been taken in by them. For apparently similar reasons he views with equal alarm those professional educationists or boss schoolmarms who, when seeking solutions for the eternal teaching enigma of trying to make Joe Doaks think, sometimes come up with proposals so pathological that even the public is provoked to merriment. But, for some very obscure reasons, Standen regards such pedagogues as also scientists and their silly extravagances as science. The net result is a confused author full of vague fears and still vaguer fevers.

> "The first purpose of Science is to learn about God and admire Him through His Handiwork. If any usefulness comes in—as it does in large quantities—why so much the better" (p. 200).

Although on occasion Mr. Standen exposes some of the nonsense uttered by so-called scientists, it appears that some of his own notions about science are not altogether different (even though they may be vaguely in a negative vein). Accordingly, science or any intellectual effort is duty bound to solve all important human problems. Any accumulation of data that does not teach us how to live or to distinguish between right and wrong or to lend itself to some moral or metaphysical interpretation is useless—unless of course it has some practical use. These ideas are not unfamiliar; they have been expounded over and over again by professional philosophers of a sort. There are, of course, many who will take issue with the suggestion that science is to compete with theology for customers, or that it is a branch of religion.

> "Evidently in biology there is the same tendency to utter pompous nonsense that characterizes scientists of all kinds. But does biology have the virtues of science? That is more questionable . . ." (p. 93).
>
> "Psychologists, following the biologists, who are themselves following the physicists, feel that at all costs they must be objective. Therefore they study man in a detached sort of way, as if they were not men themselves. Mr. Sidney Hook has seriously wondered (in Education for Modern Man) whether man is intelligent. He says this is an empirical question on which considerable evidence has accumulated. One would think that Mr. Hook, having made the acquaintance of some men, would know whether they are intelligent or not" (pp. 118–119).

It is distressing to see class distinction rear its ugly head throughout this book. May I earnestly suggest that all such obviously superior persons as chemists working at the Brooklyn Polytechnic Institute bend over backward to be tolerant of their colleagues in the other disciplines—even if such colleagues be clinicians or psychoanalysts.

Standen must surely be aware that there are those who consider the competence of certain individuals to pass on the intelligence of others an empirical question on which considerable negative evidence has accumulated. The book's dust jacket says, "What makes the book even more delightful and rewarding is the author's sense of humor. . . Standen's style brilliantly reconciles readability with precision of thought." Admittedly, there are a few humorous bits. However, the neighbor's child can come out with an occasional bright saying or two, which does not necessarily make it a Huneker or a Mencken.

Here is an elegant title indeed and much could have been written under it. Science may truly be a sacred cow, but what we have in this book is a superabundance of the male of that species.

DAVID B. TYLER

* * *

PROBLEME DER NATURWISSENSCHAFTEN. *Erläutert am Begriff der Mineralart.*

By Paul Niggli. Verlag Birkhäuser, Basel. Fr. 18.50. xii + 240 pp.; ill. 1949.

In the summer of 1942 Professor Niggli gave lectures in Zürich on "the concept of species in mineralogy." They now appear, in expanded form, as Volume 5 of the series "Wissenschaft und Kulture." This book purports to show that classification, which plays an important role in biology, is also essential in the "exact sciences." The first 50 pages are philosophical; their presentation is difficult to follow. The remainder of the work constitutes a treatise on crystallography. One wonders for what readers this treatment is intended. The author states that it is not for his "Fachgenossen"; but, although mathematical symbolism is largely avoided, it is hard to see how a reader not versed in crystallography could appreciate it fully. The biologist courageous enough to tackle it may occasionally find interesting comparisons between the concept of mineral species and that of species in biological sciences.

The figures, mostly crystal-structure drawings, are excellent. The language, abstruse and ponderous, reaches dazzling heights of hyphenated pomposity. For example, it appears that there are two scientific methods: one is the "abstrakt-generalisierende, atektonisch-imperative, ursächlich-erklärende Methode"; the other is the "vergleichend-systematische, tektonisch-normative, urbildlich-erläuternde Methode"! The publisher did a good job of bookmaking.

J. D. H. & Gabrielle Donnay

* * *

UNESCO: its Purpose and its Philosophy.

By Julian Huxley. Public Affairs Press, Washington, D. C. $2.00 (cloth); $1.50 (paper). 62 pp. 1947.

The last 2 volumes of the *Bulletin of Zoölogical Nomenclature* each contain a page on which gratitude is expressed to the United Nations Educational, Scientific, and Cultural Organization for financing the publication. This was the first intimation I had received that this organization was making any progress at all in its efforts to promote "all aspects of education, science, and culture" throughout the world. There is ample evidence of the need of just such a work as this, written by the director-general of the United Nations Educational, Scientific, and Cultural Organization, for the purpose of expounding the philosophy of this arm of the United Nations. Unfortunately, the treatise is not likely to be read by those who are most in need of its message.

At the date of publication, Huxley was not only the Director-General of UNESCO but also the executive secretary of its Preparatory Commission. A warning on the back of the title page of the treatise states that neither the organization nor the commission is responsible for the views expressed by their executive. This apparent lack of confidence is regrettable; it would have been better if the commission had read and approved the treatise in advance, so as to give the document the weight of official sanction. That they failed to do so, however, is quite understandable; after all, to vest supervision of the educational, scientific, and cultural activities of the whole world in an international organization is somewhat revolutionary. It has not been tried before. If it can be done properly it will mean that the inhabitants of the more slowly developing areas of the world will participate equally with the enlightened populations in the fruits of the intellectual activities of their cultural leaders. If done badly, it may result in the supervision of our arts and science by a superstate.

No sane person would differ with Huxley's statement as to what he hopes can be accomplished by UNESCO to assist all people to make their contribution to civilization and human welfare by making available to all the best they can offer and by improving that which is not the best. But many will feel that he has been unduly optimistic in believing that these desirable ends can be achieved in the foreseeable future under the present set-up. After all, the United Nations organization was established under an evil sign of the intellectual zodiac; a world war had just been fought and the conquered nations were too weak to participate in setting up an international organization for any purpose. Consequently they are likely to continue to think of UNESCO as a device of the victors to impose their culture on the rest of the world. This is my personal opinion and the reader should not hold the author responsible for it. He has undertaken a difficult and thankless task, for which he deserves the gratitude of all right-thinking people, who should do all they can to support and encourage him.

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BIOLOGY: HISTORY AND BIOGRAPHY

The Life of Science. *Essays in the History of Civilization.*

By George Sarton; foreword by Max H. Fisch. Henry Schuman, New York. $3.00. x + 197 pp. 1948.

This volume was published as the keynote in a new series, The Life of Science Library, which has already expanded to nearly a dozen volumes through the worthy enterprise of its publisher. The theme is a valuable one, that of the close relationship which exists between the development of science and the history of civilization—and no more fitting person could be found to introduce the series than George Sarton. His scholarship stands above reproach; his lifelong efforts to make apparent the value of studying the history of science are to no little extent responsible for the growing appreciation of it at the present time; but most of all, Sarton sets so high an example of the worth of good writing in enlarging the appeal of the history of science to thinking people. It is a dangerously high standard for those who follow him.

None of the essays included in this volume are new. They range in date from 1916 to 1934, and appeared in many journals, scholarly and popular. However, they have been carefully arranged and edited to provide unity and to avoid redundance. There are 3 essays grouped under the heading The Spread of Understanding. These broach the theme closest to the author's heart. As he phrases it: "In short, the purpose of the history of science, as I understand it, is to establish the genesis and the development of scientific facts and ideas, taking into account all intellectual exchanges and all influences brought into play by the very progress of civilization. It is indeed a history of human civilization, considered from its highest point of view. The center of interest is the evolution of science, but general history remains always in the background." This is humanism of the highest order, so seldom seen among scientists.

The next group of essays is called Secret History, because "the essential history of mankind is largely secret"—the thoughts in the solitude of study or laboratory that forever enrich the intellectual and spiritual life of man. As examples, Sarton sketches the thought-life of Leonardo da Vinci, Évariste Galois, Ernest Renan and Herbert Spencer.

In the essay East and West in the History of Science, Sarton throws into relief the internationalism of science, not at all restricted to the last two centuries. The debt of Western Science to the Arabs, and back of them to the Greeks, and in still remoter antiquity to the Egyptians and Mesopotamians needs to be better heeded by the self-assured scientists of the West today. But the fate of Greek science stands as a warning to us: "What happened to Greece is that the intellectual activities of its people were hopelessly out of proportion to their political wisdom and their morality." The sterner moral and ethical principles in the stream of Hebrew history had to be fused in Christendom with the scientific spirit of the Greeks before modern science could be born. Is the blend, never too complete, breaking down altogether in the 20th century?

In the two last essays, Sarton writes of Casting Bread Upon the Waters, a sacrifice well-known to him. How good to look back and see, from the vantage point of one's later years, that it was indeed well done!

BENTLEY GLASS

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SCIENCE IN LIBERATED EUROPE.

By J. G. Crowther. The Pilot Press, London. 18s. 336 pp.; ill. 1949.

In 1946, J. G. Crowther visited a number of countries which had recently been freed from Nazi occupation. As we would expect, the scientists of these countries did not have too easy a time. Their laboratories had been raided and valuable equipment stolen; many of the younger scientists had been conscripted and sent to labor camps; scientists of all ages had been coerced, some had yielded and collaborated with the enemy, others had resisted and been confined in concentration camps, while still others had been able to continue their work under depressing and harassing circumstances. A considerable fraction had joined the underground resistance and had become intimately associated with patriots from other walks of life.

Science, of course, suffered, but as soon as the Nazis were driven out recovery began. Make-shift equipment was constructed, new personnel was assembled and, in spite of shortages of all kinds, scientific research was resumed. It is very important that we know the status of science in the liberated countries if we are to understand the problems facing our European colleagues and if we are to help them intelligently.

Crowther has described post-war science in four countries which, together, give an adequate sample of the whole. They are France, Denmark, Holland, and Czechoslovakia. In each country he visited the leading institutions and interviewed the leading scientists. He discusses such topics as the present organization and support of research; the type of education and the living conditions of students; problems now under investigation; equipment in use or urgently needed; and the morale of scientists and their personal experiences during the occupation. The author's narrative is very detailed and precise. It includes not only a description of the physical plants, but also records of conversations with the liberated scientists and accounts of what they had suffered. It gives the impression of having been written on the spot, or at least of being composed almost immediately afterwards from copious notes. The author is obviously a good and accurate reporter.

Over and above the virtues just enumerated, *Science in Liberated Europe* has an additional value which is seemingly accidental. It was certainly not intended by the author. In brief, it consists of an unconscious exposure of the naiveté which has permeated so much of the thinking of scientists when they leave their fields of special competence. The author, a journalist who writes on scientific subjects, really offers himself as a truly beautifully prepared specimen put on exhibition by a three-year time lag.

Throughout the work the author expresses judgments not only on scientific matters, but on political ones as well. He has very definite ideas concerning certain competing ideologies, the proper relation of scientists to society, and such subjects as the support and direction of scientific research by the state. He expresses himself very freely on these and other controversial matters. He tells us just what his own beliefs and conclusions are, both directly and by implication. Unfortunately, his impressions and judgments, gained in 1946, are printed in 1949, and reviewed and evaluated in 1950. Recent events have not been kind to many of those who committed themselves to simple philosophies or who became true believers in one or another panacea. We should remember, however, that the opinions expressed by Crowther were held by a great many good scientists during the period when Russia was "our gallant ally" and when communists and non-communists were comrades in the underground.

No series of short quotations would give a complete or even fair picture of Crowther's political philosophy. Those which follow are just examples which impressed the reviewer.

"Quite possibly, in the long run, the experience of the French scientists in the resistance will prove of more importance for the future of science than the experience of the British scientists in their great war-time technical scientific efforts.

"The symbolic expression of the situation is perfectly exemplified with regard to atomic energy—in England, Sir John Anderson became chairman of the Prime

Minister's committee on atomic energy: in France, Professor Joliot-Curie occupied the corresponding position." (p. 13).

The recent somewhat embarrassed French government's explanation of Prof. Joliot-Curie's public statements on his personal loyalties and atomic research is in nice contrast to the author's implied approval of Prof. Joliot-Curie's appointment. A little later, in April 1950, Prof. Joliot-Curie was removed from office because his loyalty to France seemed questionable. In a panegyric Crowther adds:

"He [Joliot-Curie] joined the French Communist Party. As a Communist, he belongs to the appropriate cell, where he joins in the discussions of political questions with working men and women, and others from entirely different sections of the population, whom a scientist does not usually meet. He finds these discussions most valuable, especially on the relations of science to other social affairs, for his political colleagues, many of them shrewd workmen, make comments and observations which are not likely to occur to scientists with their professional, middle-class background." (p. 54).

In describing science in Dutch Universities, the author states:

"Nevertheless, the professors tend to identify the universities with themselves and believe that they can speak not only for themselves but for all of their subordinates and their students. The ideal organization would include all of the persons of the staff of the university, from the professor to the laboratory mechanic." (p. 286).

"The appreciation of Soviet principles and ideology have strengthened their [Czechs'] intention to develop science and technology by rational planned action." (p. 292).

A very interesting account is given of the author's visit to the monastery at Brno where Mendel made his revolutionary discoveries; but in 1946, of course, only a few were aware of the Communist threat to Mendelism and Crowther was not among them. His description of the monastery at that particular time is thus objective and valuable, as it gives us a picture of the place just before genetics was outlawed. Perhaps sometime in the future the monastery will again be liberated, and we can hope that then an observer as competent as Mr. Crowther will report on its state.

All in all, *Science in Liberated Europe* is valuable both for the author's objective reporting and for his subjective judgments. Historians of science can use both as source material in evaluating our epoch.

CONWAY ZIRKLE

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THE STORY OF THE JOHNS HOPKINS. *Four Great Doctors and the Medical School They Created. By Bertram M. Bernheim. Whittlesey House, McGraw-Hill Book Co., New York and Toronto.* $3.50. xii + 235 pp. + 9 plates. 1948.

The Johns Hopkins Medical School is not like those of other universities. The title of this book itself indicates that it is a peculiar institution. No one ever speaks of The Harvard, The Cornell, The Temple, or The Stanford, but it is always The Johns Hopkins, or even The Hopkins. Other medical schools have generally originated as accretions to older institutions which were experiencing the growing pains of the transformation from college to university status. But The Hopkins never was a college. It was born full-fledged without any larval stage, from the mind of its founder whose name it bears as Pallas Athene from the forehead of Zeus.

Johns Hopkins himself seems to have been the only figure of importance in this narrative with whom the author did not have a personal acquaintance. The pictures he gives us of the "Big Four" are vibrant with life and activity, and full of color, but that of the founder reminds us of a daguerreotype with the musty odor of the library stacks. This is not surprising, for Johns Hopkins did not come of a literary family. Neither he nor any of his relatives left any memoirs from which a passable biography might have been compiled, and a half dozen pages serve to exhaust all the data about him which the author has been able to assemble. After the opening chapter his name does not appear again. The reason why this relatively unlettered man chose to establish an institution of higher learning is obvious. His was a frustrated life. Unable to attend school because his labor was needed on the farm, and unable to marry the girl of his choice because her father objected to him, he became an embittered introvert. He then devoted himself to the liquor industry, thereby amassing the fortune by means of which he perpetuated his name.

Even after his death he was frustrated, for his executors, who had neither vision nor faith in the future of either the university or the city of Baltimore, broke his will and placed both the university and the hospital in blighted areas isolated by the freight yards. Eventually the university acquired the Homewood campus, but the hospital has been doomed to remain where the executors placed it, surrounded by the squalor of an environment that continues to deteriorate, and with little opportunity for expansion because all available ground is occupied. This has not been altogether a bad thing. The department of a hospital that makes the greatest number of contacts with the outside public is the dispensary, and the patronage of the dispensary is recruited chiefly from the lower strata of society. The residents of elite communities can be visited by physicians in their homes, or can obtain hospitalization elsewhere, but there is no one to minister to the needs of the underprivileged of East Baltimore except The Hopkins, and this is the way Johns himself would have wished it. He would never have been a welcome guest at the homes of the socially elite, but the slum-dwellers and the wharf rats respected him and loved him.

The story which the author tells us is not that of an institution, but of the men who made it famous. Probably no similar school has ever had so many luminaries on its faculty. One need only recall such names as Welch, Osler, Halsted, Kelly, Mall, Howell, Abel, Cushing, Baetjer, Dandy, to mention a few chosen at random, to realize this. The problem confronting me is to decide upon which of these to comment. Shall I speak of "Popsy" Welch, or of "The Chief," as Osler was known? Or shall I speak of Kelly, who always "opened with prayer," or of Abel's discovery of adrenalin for which he has never been given credit? Shall I speak of Baetjer, the pioneer in x-ray work, who had to undergo more than 40 operations for burns on his hands? Or should I speak of the time when the author, feeling that he was not getting as much as he should from the course on human anatomy, bribed a janitor to procure for him a cadaver from the dissection room which he took to his home in Kentucky, packed in a suitcase for summer study, unmindful of the fact that he was committing a penitentiary offense? Or of the time when a physician who had exhausted every remedy in the Materia Medica for hiccoughs finally administered a glass of water with the statement that it was a newly discovered drug that cost 30 dollars a dose? (The hiccoughs stopped at once and there was no recurrence.)

One of the best known stories about The Hopkins concerns the statement falsely attributed to Osler that men over 60 should be chloroformed. Actually, what Osler said was the relatively mild remark that college professors should be retired at the age of 60. That part of the commencement address in which the chloroform figures so prominently was a bit added by a writer of fiction. It certainly seems strange that such a misunderstanding should have occurred in the case of a man from The Hopkins, an institution noted for its respect to age. It is true that most of the Hopkins celebrities were young men when they first became associated with that institution, but it is also true that most of them remained until well past the three score and ten years allotted by the psalmist. Isaiah Bowman was over 60 when called to the presidency of The Hopkins, and a few years earlier another sexagenarian had been similarly honored, though he declined the call.

With apologies to those who may not be interested, I recall my own experiences at The Hopkins. Circumstances beyond my control prevented me from entering a graduate school immediately upon leaving college. When the way opened 14 years later, I circularized a dozen of the leading institutions of higher learning of the country. The replies were disheartening. "We are sorry but we can do nothing for you. You are too old." One even went so far as to attempt to dissuade me by suggesting that stenography might be a more practical study. But the reply from The Hopkins restored my faith in the American university. "You are the kind of man we are looking for. Come at once and let us get better acquainted." The letter was signed by Raymond Pearl, the founder of this journal, and it explains why those who hold a Hopkins degree look back on their student days with gratitude and appreciation.

ECOLOGY AND NATURAL HISTORY

BEYOND THE CASPIAN: *A Naturalist in Central Asia.*
By Douglas Carruthers. Oliver & Boyd, Edinburgh and London. 22s. 6d. xx + 290 pp. + 21 plates + 1 map; text ill. 1949.

This book is an account of wanderings during the first decade of this century in Central Asia, a region with indefinite boundaries herein taken as the land stretching from the Oxus River on the east to the Gobi Desert on the west, between those more or less parallel mountain ranges, the Tien Shan and Kun Lun. The author is a collector of birds and mammals, with a compelling desire to roam the deserts of the earth. The greater part of the text is concerned with the natural history of the birds and mammals he met, wild sheep and pheasants receiving especial attention. Eighteen photographs and 6 reproductions in color of paintings aid in describing the landscape and some of its inhabitants. Little mention is made of contemporaneous human inhabitants, although a brief history is given of their forebears, who under Tamerlane terrorized much of Eurasia. Appendices review the classifications of Old World members of the genus *Ovis* and of the true pheasants.

J. L. BROOKS

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ANTARCTIC CONQUEST. *The Story of the Ronne Expedition of 1946-1948.*
By Commander Finn Ronne, U.S.N.R. G. P. Putnam's Sons, New York. $5.00. 20 + 299 pp.; ill. 1949.

Finn Ronne has given an account of a remarkable modern expedition to Antarctica, where he and his group spent 15 months (1946–1948). Although the biologist will find little direct information about the fauna or flora, since except for some plankton collecting a biological program was not planned, the document is a remarkable report on the "human ecology" in a remote and isolated scientific expedition. Moreover, the description of the infinitely detailed preparations and carefully meshed operations in the field gives the laboratory trained reader a feeling of "good research design." Ronne and his group (including Mrs. Ronne and Mrs. Darlington, the pilot's wife) mapped 250,000 square miles of heretofore unknown country, and corrected over 200 000 square miles of mapping. Geological geophysical, and meteorological studies were carried out by the scientists on the expedition. A most commendatory note on the expedition is the plan regarding the workup and publication of the data. By the time Ronne's *Antarctic Conquest* was printed, 7 scientific papers on geophysics and geology had been published, 10 on other subjects, and 7 more were in process.

M. C. SHELESNYAK

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FIELD MANUAL OF PLANT ECOLOGY. *McGraw-Hill Publications in the Botanical Sciences.*

By Frank C. Gates. McGraw-Hill Book Co., New York, Toronto, and London. $3.00. xvi + 137 pp.; ill. 1949.

PLANT ECOLOGY. *Fourth Edition.*

By W. B. McDougall. Lea & Febiger, Philadelphia. $4.00. 234 pp.; ill. 1949.

The first edition of McDougall served an extremely useful purpose (reviewed *Q.R.B.*, 3: 141; 3rd ed., 16: 496). Compact and fairly well written, it afforded a general introduction to plant ecology for the large numbers of general students with whom ecology still plays the game of "hard to get."

While the current edition has been reset (not without errors), it does not show the degree of revision which its possibilities would merit. Since this situation has already been documented with some care in another review (Egler, F. E., *Ecology*, 31: 312. 1950), it need not be further labored.

Gates' manual of field methods is likewise compact and well rounded in its emphasis. It is, moreover, a product of the kind of continuous revision that comes from working for 32 summers with the challenging students who have enrolled for field classes in plant ecology at the University of Michigan Biological Station. In that period these classes have achieved a deservedly high reputation for thoroughness.

Since the publication of Clements' pioneer *Research Methods in Ecology* in 1905 there has been—so far as I know—no general handbook of methods available for students. Aside from excellent but brief suggestions in textbooks, original papers have been the only, and necessarily scattered, source of directions. This fact alone should make clear the utility of Gates' *Manual.*

Methods are to the scientist what tactics are to the soldier. Today, even in the physical sciences, it is understood that technique must be adapted to the problem in hand as well as to the nature of the material used. This is, a fortiori, certainly true of ecology, where regional aspects play so great a part. It would be praise enough to say that Gates has written an excellent manual for northern Michigan, which he has. But this manual is so soundly conceived and so well done that it will be readily adaptable by any competent teacher for much wider use.

PAUL B. SEARS

LE PEUPLE DES TERMITES. *"Que Sais-Je?" Le Point des Connaissances Actuelles. Number 213.*

By J. Feytaud. Presses Universitaires de France, Paris. 45 fr. (paper). 128 pp.; ill. 1946.

In popular form, this is a well-written comprehensive survey of termites. Several genera are considered individually in terms of general characteristics, caste systems, nest construction, modes of digestion, reproduction, and defense of the colony. In the chapter La Vie au Grand Jour the internal operations of the colony receive review as a working superorganism. There follow 3 chapters presenting "both sides of the case": the symbionts and predators, termite damage to man's belongings, and La Réaction de l'Homme, which might well have been entitled L'Homme contre le Termite. *Le Peuple des Termites* makes little attempt at straight technicality, though a sufficient amount of detail is given. Bits of philosophy are mixed with an excellent historical review of our knowledge of termites and a consideration of the varied terminology applied to them in different countries. The bibliography includes 17 references to more technical papers by Feytaud, as well as a good representation of articles by other workers. There is no index.

L. S. STAPLES

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FLUCTUATION OF ANIMAL POPULATIONS. *Australian and New Zealand Assocation for the Advancement of Science. Presidential Address: Section D-Zoology. Perth Meeting, August, 1947.*

By A. J. Nicholson. Australian and New Zealand Association for the Advancement of Science. Paper. 14 pp. 1947.

In a long and somewhat difficult paper published in 1933, A. J. Nicholson (*J. Animal Ecol.*, 2: 132–178) set forth a general theory of biotic interactions as these regulate the "balance" of animal populations. Nicholson's monograph was essentially deductive in method and not lacking in intuition. While it is quite justified to state that this contribution remains an ecological classic, it is equally fair to conclude that the opinions advanced therein are not shared in entirety by all population ecologists and that many of the formulations remain to this date abstractions yet to be verified by field and laboratory study.

The crux of Nicholson's theory is that, while the physical environment produces marked fluctuations in census numbers, it is interaction between organisms that alone initiates and perpetuates some semblance of numerical control over the longer time span of a population's life history. Nicholson seems to synonymize such interactions with "competition." Thus, he confers upon this term a statistical meaning under which any relationship leading to the decreased probability of individual survival (or reduced reproductivity) through increase in population density could be called "competitive." This is an extension of the definition beyond the limits commonly recognized by most ecologists.

The present brief paper was delivered as a presidential address before the Australian and New Zealand Association for the Advancement of Science. It has two distinct merits: it expresses descriptively Nicholson's main ideas in simple, non-technical language; and it makes an intelligent plea for further work.

The key points made by Nicholson in his lecture can be arrayed as follows:

(1) Competition between animals, especially for food, is the mechanism that regulates abundance and leads to a state of balance.

(2) Such balance may be relatively stable, or quite unstable.

(3) If only replacement (by reproduction) occurs after a population has reached "the level of bare subsistence," the balance remains at equilibrium. Also, intraspecies strife induced by high density tends to produce stability by differentially eliminating weaker individuals through death, emigration, or both, and by favoring the more robust. The territorial behavior of mammals and birds is advanced as an illustration of this last point.

(4) Populations inadequately checked by factors other than food tend to exterminate themselves by exceeding their food supply. This may actually happen in small, special areas. In larger areas, marked oscillations in density occur owing to the release of population pressure as the density falls—this release permitting, first, the food resource to recover, followed, second, by recovery of the population itself. Such an oscillation can occur in space or in time.

(5) When predation destroys only the ill-fit among the prey, the latter achieves a density that jeopardizes its food supply. Contrariwise, when enemies attack "normal" individuals there is a tendency to keep the prey population at reduced level; the enemies have difficulty in satisfying their food requirements, and, in consequence, their numbers are limited. Under such conditions the prey population does very slight damage to its food plants.

(6) Mass emigration occurs with some species when population pressure builds to a critical threshold. This prevents the depletion of the food supply to a level that would cause mass starvation, but it does lead to violent oscillations.

(7) Epidemic disease can also produce oscillations. The incidence of disease is correlated with high host density and with the resultant malnutrition of the host species.

(8) "Superimposed upon this complex system of balance are climatic fluctuations; while below it, and supporting the whole system, are the physical environment and evolution, which together have determined which plants and animals can live together and react with one another in any particular place."

Nicholson concluded his address with the following statement: "In our investigation of the population problem we must make full use of all means at our disposal, which can broadly be classified as field observation, experiment, and theory. Field observation should lead to experiment, and both these methods provide the materials for theory, which in turn suggests further experiment and checking by observation. These methods are inseparable, and we must use all three readily and with judgment to develop our knowledge effectively. At the moment, it appears to me, theory has outstripped observation, while experiment has been grossly neglected."

It is my present opinion that ecology will sustain creditable advances during the next several decades in certain rather broad areas of research. These include a study of microclimate, of community metabolism or "energetics," and of populations. The application of maturing ecological principles to man's welfare will also accelerate. In all such investigations the combination, as suggested by Nicholson, of field observation (plus field manipulation), laboratory experimentation, and theory will be both functional and necessary. By the nature of the case it is likely that such combination may be more readily achieved and perfected in the analysis of population phenomena.

THOMAS PARK

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A STUDY OF SMALL MAMMAL POPULATIONS IN NORTHERN MICHIGAN. *Misc. Pub. Mus. Zool. Univ. Mich., No. 73.*

By Richard H. Manville. University of Michigan Press, Ann Arbor. $1.25 (paper). 83 pp. + 4 plates; text ill. 1949.

A program of live-trapping and marking of small mammals (mostly rodents and insectivores) was conducted during the summers, 1940–1942, in the Huron Mountain region of the Upper Peninsula of Michigan. The work was done on 8 quadrates each 300 feet square (2.07 acres) and usually representing different types of forest habitat. Plant and animal associations of each type are described, and population data are presented on the species trapped. The woodland deermouse (*Peromyscus maniculatus gracilis*) was, on the whole, the most abundant mammal, though a spectacular increase of the short-tailed shrew (*Blarina brevicauda kirtlandi*) made the latter the dominant form in 1942. The relative abundance of the resident mammals changed constantly, but the brevity of the study did not permit critical treatment of these fluctuations. A tendency was noted for many species to become more numerous at the same time, particularly by the fall of

1941. The chief weaknesses in the discussion of fluctuations, in my opinion, lie in "balance sheet" assumptions, i.e., of more definiteness than exists in numerical values for home ranges, reproductive potentials, etc., that actually may be influenced a great deal by at least several important variables. The author's stated preference for the old concept of balance of nature seems to ignore the many resiliences occurring in population phenomena; but, on the other hand, his suspicions of oversimplifications in explanations of "cyclic" changes are entirely wholesome. Environment, considered in terms of "key factors," certainly may not be divorced from the life equations even of species known to fluctuate with a fair amount of periodicity.

PAUL L. ERRINGTON

EVOLUTION

THE PTEROBRANCH RHABDOPLEURA IN THE ENGLISH EOCENE. ***Bull. Brit. Mus. Nat. Hist., Geol.*** *Vol. 1, No. 1.*

By Henry Dighton Thomas and Arthur George Davis; with an appendix on The London Clay at Lower Swanwick Hampshire by Arthur Wrigley. The British Museum (Natural History), London. 7s 6d. (paper). Pp. 1–24 + 3 plates; text ill. 1949.

A RE-CONSIDERATION OF THE GALLEY HILL SKELETON. *Bull. Brit. Mus. Nat. Hist., Geol., Vol. 1, No. 2.*

By Kenneth Page Oakley and Montague Francis Ashley Montagu. 5s. (paper). Pp. 25–48 + 1 plate; text ill. 1949.

The new ***Bulletin of the British Museum*** (***Natural History***) is to be issued in 5 series corresponding to the Departments of the Museum. They will appear at irregular intervals, volumes (300–400 pages) not necessarily being completed within one calendar year.

The series in *Geology* begins with a paper describing the first fossil rhabdopleure, found in the English Eocene strata. Besides being of exceptional interest because of the lowly place of the pterobranchs in the phylum Chordata, this is also noteworthy because it helps to close the gap between the modern pterobranchs and the last dendroid graptolites of the Carboniferous.

The second paper publishes evidence that the famous Galley Hill (Swanscombe) skeleton is comparatively recent, in spite of its 8 ft. deep burial in the gravels of the 100-foot (mid-Pleistocene) terrace. The skull and mandible "show no features which cannot be matched in the contemporary population of Britain." Especially convincing are the results of fluoride tests, which revealed about 0.2 to 0.4% of fluorine, like Holocene bones, rather than 1.0% like Upper Pleistocene or 2.0% like mid-Pleistocene bones from the Swanscombe region.

BENTLEY GLASS

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AUTOUR DE LA CRISE DU TRANSFORMISME. *Second Edition.*

By Pedro Descoqs. Beauchesne et Ses Fils, Paris. 33 fr. (paper). x + 102 pp. 1944.

The biblical account of the origin of man has always been a complicating factor in any discussion of evolution. Some Catholic theologians, such as Dorlodot and Messenger, have held that there is no contradiction between the story of creation in the Book of Genesis and the theory of evolution. Others, such as the present author, have continued to oppose evolution, particularly as it refers to the origin of man. Father Descoqs defines transformism as a mechanism of evolution consisting of a succession of minute changes in living organisms. He has assembled, from the writings of contemporary French scientists, a number of quotations to the effect that transformism is a hypothesis rather than an established fact. The author then proceeds to restate the traditional teachings of Catholic theologians concerning the origin of the world, the direct creation of man, and original sin.

WALTER H. BELDA

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PROGRÈS OU RÉGRESSION?

By Frédéric-Marie Bergounioux; preface by S. E. le Cardinal Saliège. Didier, Paris. 80 fr. (paper). 128 pp. 1947.

This book is a commentary on the theory of regressive evolution proposed in 1943 by Salet and Lafont. According to this hypothesis, the history of the earth consists of three major periods: first, the period of the creation and formation of the earth, up to the appearance of man; second, the Golden Age, during which nature achieved perfection when man appeared on earth; third, the period of regressive evolution, beginning with the fall of man. An important corollary of this hypothesis is that plants and animals which existed before man appeared on earth were immortal, and that after the fall of Adam and Eve, not only mankind, but also all other things, first became subject to death. The hypothesis of regressive evolution was published by Salet and Lafont with the Catholic imprimatur of Msgr. Gaudel of the University of Strasbourg, who commented that while this hypothesis is not contrary to Catholic theology, it is not the only hypothesis which explains established facts, and that whatever validity it has depends on the proofs alleged in its favor.

Professor Bergounioux is a geologist at the Institut Catholique of Toulouse. The first section of his book is a critique of the hypothesis of Salet and Lafont. The author points out that the succession of living forms established by paleontology is completely contrary to any hypothesis of regressive evolution. The second section is a summary of paleontological evidence dealing with evolution.

WALTER H. BELDA

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LA VIEILLISSEMENT DU MONDE VIVANT. *New [11th] Edition.*

By Henri Decugis; preface by Maurice Caullery. Librairie Plon and Masson et Cie., Paris. 120 fr. (paper). vi + 387 pp. + 10 plates; text ill. (1941); 1943.

The notion that evolution automatically results in "progress" has been dead a long time, and ought to be allowed to rest in peace. But here is another book—first published in France in 1941—to explain that evolutionary change is not often progressive. The first two chapters deal with species that have become extinct, have not changed for a long time, or have regressed. The larger part of the book is then devoted to considering the causes of extinction or evolutionary arrest. With a certitude that hardly seems warranted by the available evidence, the author ascribes the arrest and disappearance of species to parasitism, infections, metabolic disorders of endocrine origin, and derangements of reproductive habits. All species, he feels, are now afflicted by these disturbances to such an extent that evolution has come to its end.

Although Decugis displays a wide range of knowledge in his selection of examples, his understanding leaves something to be desired. The major flaw in the book is that the products of evolutionary processes are actually judged in the light of the human concept of progress, and thus condemned for reasons irrelevant to nature. Adaptation and survival are scarcely mentioned. Anthropocentrism moreover clouds the entire work; the termites, for example, "mènent une existence lente et lugubre dans la nuit noire des galeries des termitières."

Against this background it is not surprising to find that Decugis, who wrote off the white race in *Le Destin des Races Blanches*, now despairs of the entire human species. Still, in an era when mankind is truly in grave peril of its existence, it is surprising to find leprosy, Malta fever, and bubonic plague listed among the major threats to our survival. Not the least interesting thing about this book is that it went through 11 printings in a 2-year period while France was under Nazi occupation. There seems to be some satisfaction in pinning the plight of the human race on causes beyond our control.

FLORENCE MOOG

GENETICS AND CYTOLOGY

AN INTRODUCTION TO MODERN GENETICS. *Second Impression.*

By C. H. Waddington. The Macmillan Co., New York. $3.25. 441 pp. + 5 plates; text ill. 1950.

It would have been better had the author revised this book, for modern genetics has advanced a great deal and a number of viewpoints have been altered in the past 11 years. Nevertheless, everyone who has tried in vain during recent years to secure a copy of this thought-provoking treatment of the subject will welcome its reappearance in print.

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STORIA NATURALE DEL SESSO. *Biblioteca di Cultura Scientifica. XVI.*

By Emanuele Padoa. Giulio Einaudi, Turin, Italy. L. 1200 (paper). 561 pp. + 2 plates; text ill. 1948.

This work is a notable example of a genre sadly lacking in our American scientific literature: a comprehensive uncondescending exposition of a fairly general subject, written seriously for serious readers who are not, however, specialists in the field. The clear, precise language of the preface gives a view of a scientific climate foreign yet not completely strange, to the American scene: the implied defense of the Morgan school of genetics, together with a defense of American scientific contribution, is a homily in itself to the reader on this side of the Atlantic. Written, as we are told, in the dark and distressing days of 1943–44 and completed just at the time of the news of Hiroshima, with all its foreboding implications for the future of science and society, the book is nevertheless a model of economical, serenely thought-out language, of wise choice of concrete examples for discussion, of clear illustrative material from the literature, uncluttered tables, and illuminating original diagrams. Padoa is a talented teacher who can summarize complicated matters in a deceptively simple style.

Characteristically, the first chapter at once justifies the title of the book by dealing with reproductive patterns throughout the biological world. Chapters on meiosis, gametogenesis, and fertilization follow. Later chapters are concerned with zygotic and phenotypic sex determination, sex differentiation, secondary sex characters, and sex reversal. Padoa has been particularly successful in presenting the classic foundations of each of these phases of his subject synthetically with more recent thought and investigation. That some modern work has been omitted is hardly surprising, in view of the isolation in which the manuscript was composed: what does surprise is that so much new work has been not only included but truly assimilated.

Of especial interest in the preface is the clear statement—one of the few explicit ones I have seen—the position tacitly taken by many biologists: that our science is fortunately a young and innocent one, to be dissociated morally from the terrors of nuclear physics. Each of these propositions seems highly questionable.

In particular, it seems that anyone who has willingly followed or employed scientific methods is somehow morally involved in the hard decisions taken by the nuclear physicists in these recent eventful years. However that may be, the detachment experienced by Padoa (and indeed by many of his colleagues in Italy) has been fruitful, and we wish him many and happier years in which to continue his investigations and his teaching, and in which perhaps even to become reconciled to the rigors of the atomic age and the witticisms of Samuel Butler. It is difficult to refrain from mentioning the unostentatious but very pleasing format of the book, or the author's handsome photographs of experimental fowls, with a delicate haze of Italian rooftops as a background.

DOROTHEA RUDNICK

◆

STUDIES IN GENIUS.
By Walter G. Bowerman. Philosophical Library, New York. $4.75. iv + 343 pp. 1947.

A quaint book indeed! The author has enjoyed his hobby of research in biography, and a mass of statistics and enumerations is the result. The 1000 eminent Americans chosen for review are considered from such points of view as the geography of their birthplaces, the season of the year at their births, and their blood relationship to others on the list. There seems to be significant evidence that the genius, as defined in this book, is born in a larger family than a person in normal families of the "upper" classes. However, exact information was available for only 274 of the eminent individuals and is probably biased in favor of the larger families. A similar situation was found for the children of the eminent persons. What information there was indicates a strong correlation between the type of genius and his body build. The cause of death was also correlated with the body form or somatotype. A similar study of world-wide genius comprises the second half of the book.

It is not expected that this book will be of particular value to biologists, though some of the sister sciences might find it useful.

SHELDON C. REED

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ERGEBNISSE UND AUFGABEN DER ZELLMORPHOLOGIE. *Wissenschaftliche Forschungsberichte, Naturwissenschaftliche Reihe, Band 56.*
By Dr. E. Küster. [Theodor Steinkopff, Dresden & Leipzig], J. W. Edwards, Ann Arbor, Michigan (Printed in Germany). $4.00. viii + 141 pp. [1942], 1947.

This book is one of a series edited by Liesegang of the Colloid Institute of the University of Frankfurt for the purpose of affording critical reviews of the literature of natural science during the past 10 years. Since the volume was first printed in Germany in 1942 and reprinted here in 1947, much of its timeliness is past. However, most students familiar with Küster's book *Die Pflanzenzelle* and his researches on protoplasm and plastids will doubtless want to read this one also. The text is based upon his lecture notes of cytomorphology, and although Küster is a botanist, the subject and treatment have validity and significance also for the zoologist. There are 8 chapters about protoplasm, the nucleus, plastids, ergastic substances, the vacuole, membranes, the cell as a whole, and protista. A list of representative literature citations follows each chapter. There are author and subject indexes.

EARL H. NEWCOMER

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CYTOLOGIE VÉGÉTALE ET CYTOLOGIE GÉNÉRALE. *Encyclopédie Biologique, Volume XXVI.*
By Pierre Dangeard. Paul Lechevalier, Paris. 1250 fr. (paper). iv + 611 pp.; ill. 1947.

No really satisfactory book on general or plant cytology has been available either for teaching or research reference. The author has attempted to fill this gap and has been, to a degree, successful. This work might well serve as a textbook for a course in plant cytology, but only as an added source reference for a general course.

The author states that he has tried to cover the various aspects of classical cytology as well as the more recent developments. In the latter respect the treatise could be much improved. For instance, the fields of cytochemistry and the newer aspects of mitotic abnormalities induced by various radiations, cell poisons, etc., are not exploited. The chapter on cytogenetics leaves much to be desired. However, these shortcomings are, at least in part, recognized by the author for he says "... que nous ne pouvons pas nous flatter d'avoir donné un aperçue de toute question d'intérêt majeur. ... Ce livre est donc plutôt une Introduction à la Cytologie qu'une Traité."

A. H. SPARROW

GENERAL AND SYSTEMATIC BOTANY

PHYTON. *Annales Rei Botanicae. Volume 1, Number 1, November, 1948; Numbers 2–4, June, 1949.*
Edited by F. Weber and F. Widder. Ferdinand Berger, Horn N.-Ö. (Austria). (1) 30 Sch. (Domestic), S. fr. 10.00 or $3.00 (Foreign); (2–4) 90 Sch. (Domestic), S. fr. 30.00, or $9.00 (Foreign).

The appearance of a new botanical journal is always an event of considerable interest, particularly so when the new journal is edited and published in the Russian zone of Austria. According to the editors, both of the University of Graz, *Phyton* is intended to represent the whole field of botany rather than a specialized branch of it. Papers are limited to 16 printed pages but can be submitted in any one of the congressional languages. Actually, volume 1 contains 2 papers and parts of a third in English, all others being in German. One of these papers had previously been published in the United States, and a translation of it appeared in a German journal (*Physis* 2/3).

In all, 26 articles and 2 groups of reviews are included in this volume. The majority (14) of the articles may broadly be classed as representing the morphological sciences, 11 being taxononic, 1 paleobotanical, 1 each in the fields of phylogeny and evolution, respectively. Of the 10 remaining articles, 4 deal with vitamins and plants and 1 with anatomical effects of colchicine treatment. Other interesting topics covered are: the correct spelling of the name Ginkgo; the occurrence of mangroves in Upper Cretaceous deposits of the northern foothills of the Austrian Alps; the action of guard cells in aquatic plants; the permeability of protoplasm with regard to various substances; and the electro-physiological behavior of glands. The single plate included in this volume is a reproduction of one of the rarest botanical plates ever made. It is the work of the botanist Ignaz Friedrich Tausch (1793–1825) and represents plate 20 (last) of his folio *Hortus Canalius . . .* (1823–1825). The legend gives the name *Actaea nutans* Tausch. The author of the paper (F. Widder) identified this long lost species (and name) as a mutant of the North American species *Cimicifuga racemosa* (L.) Nutt., possibly referable to var. *serpentaria*.

Clearly certain fields are not represented in this volume, notably cytology, genetics, ecology, cryptogamic botany, and microbiology. Perhaps future volumes will remedy this deficiency. Although the workmanship and paper used in the production of this volume are remarkably good considering the difficult post-war conditions, most potential subscribers will be stunned by the differential subscription rates, ranging from 120 Schilling for Austrian subscribers to 40 Swiss francs and U. S. $12.00 for foreign subscribers. American subscribers are thus expected to pay about three times as much as the domestic rate. As no comparable American or other scientific journal sells for that much either at home or abroad, this policy is likely to curtail the circulation of this otherwise commendable journal from the very outset.

THEODOR JUST

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COLLEGE BOTANY.

By Harry J. Fuller and Oswald Tippo. Henry Holt & Co., New York. $5.75. 993 pp. + 1 plate; text ill. 1949.

When a teacher finds that students have read several chapters ahead of the assignment in a textbook he knows that that textbook has something not usually present in such works. Fuller and Tippo have made a comprehensive and informative textbook readable, in fact, enjoyable. *College Botany* is still a textbook, however, and not a book that skims lightly over some of the more amazing facts about plants. The reader gets a good introduction to an understanding of the structure and the operation of flowering plants. For anyone who wants to learn about such things as the relations of roots and soil, what botanists now know about the absorption of nutrients from the soil, how materials are moved within the plant, and what happens to them when they get to their destination, the early chapters give the story succinctly with diagrams and pictures that clearly illustrate the text. The discussion of the chemical processes can be understood by someone without much background, although the presentation is not toned down to the point where a student who knows chemistry could think that biochemistry is simple. The complex interrelations between plants and their environment is continually emphasized by reference to controlled experiments that have been carried out and by pointing out the agricultural and horticultural practices that are based on manipulations of either the plants or the environment. In fact, all through the book student interest is aroused and held by references to the usefulness of knowledge about plants and plant growth. A more complete discussion of the importance of plants to man is given at the end of the book. Often such chapters are not read by students because the preceding chapters of a book have so completely divorced plants from the world of everyday life that it is too late at the last to arouse interest in the reason why the knowledge of all kinds of plants is of consequence to man. But Fuller and Tippo lead up to their last chapter, making it a suitable conclusion to their treatment of modern plant science.

No review of *College Botany* would do it justice that did not praise the clarity and meaningfulness of the illustrations. Each one tells a story, and most of them tell stories that are not easily demonstrated by many teachers. All of them show what their legends say they show. Another feature that aids the student is the inclusion of summaries at the ends of chapters to make the main points stand out. All technical terms are printed in bold face type when introduced and are clearly described at that time. The glossary and a very complete index make the text workable and give the student a feeling that the authors had clear minds and knew what they were aiming at from the time they started organizing and writing the book until they finished the tedious labor of completing the index. When high standards are set and met by textbook writers, the users respond with a respect for and an awakened interest in the subject matter. Fuller and Tippo's *College Botany* stimulates such a response.

Harriet B. Creighton

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College Botany. *A Basic Course in Plant Science By Clarence J. Hylander and Oran B. Stanley. The Macmillan Co., New York.* $5.00. xii + 638 pp. + 1 plate; text ill. 1949.

This textbook is intended for the traditional year course in general botany with Part I, The Plant Organism, dealing with the structure, functions, and problems of the individual seed-bearing plant, for the first semester, and Part II, The Plant World, for the second semester. This second part deals with plant groups, first from a taxonomic and morphological standpoint and then from that of plant interrelationships, and concludes with 6 chapters on plant ecology, heredity, and evolution. That the book can be used, however, for shorter "enriched" courses is pointed out by the authors. (Particular "blocks" and "gaps" could easily be chosen in line with certain trends in general education.) There are 453 figures, an appended list of common and scientific names of plants mentioned in the text, but few chapter summaries, no glossary, no suggestive list of topics or questions for study, and no bibliography or suggested reading lists for interested students. Many teachers may find these lacks a drawback, but perhaps the text is intended to include all necessary facts and to be sufficiently stimulating without wording of questions. The photographs, line drawings, and charts are uniformly excellent, and one welcomes the new illustrations. The headpieces at the beginning of each chapter are particularly attractive. Certainly it is a book with a wealth of information about plants, the organization is good, errors are few, and it is readable. Perhaps there is a better balance here between morphology, physiology, ecology, and the economic aspects of plants than in many textbooks. The emphasis is on a thorough study of seed plants, their practical and cultural values, and the importance of conservation or an intelligent use of our plant resources.

In the Preface, the authors have stated that their intention is to secure a more balanced content of subject matter, to appeal to the needs and interests of larger numbers and varieties of students, to develop an awareness of the importance of plants, and to utilize to better advantage visual instructional materials. In most respects the book has accomplished these aims admirably, but as with certain other recent voluminous books on botany one wonders if the increased number of pages involved in supposedly attracting and holding all sorts and conditions of students has not made it of such an encyclopedic nature that the average student finds more factual "meat" than he can chew or digest, and hence is provoked to greater coverage rather than being stimulated to thoughtful study involving a mastery of principles and a formulation of concepts.

Carrolle E. Anderson

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A Manual of the Penicillia. *By Kenneth B. Raper and Charles Thom; with the technical assistance and illustrations by Dorothy I. Fennel. The Williams & Wilkins Co., Baltimore.* $12.00. x + 875 pp. + 10 plates; text ill. 1949.

There are probably few microorganisms and certainly few fungi which transcend the Penicillia in their importance to man. Within this single genus of fungi are found not only producers of powerful antibiotics of incalculable value in modern medicine, but "molds" of enormous commercial value. As illustrative of their diversity of activities and metabolic dexterity one might cite their importance as producers of organic acids, enzymes, their role in cheese-making, and in the deterioration and spoilage of foods, various manufactured products, etc. They also produce serious destructive fruit rots, and cause certain diseases of crop plants and even of man.

In spite of the enormous importance of *Penicillium* in our everyday life, the complex of species has remained for all but a few persons a baffling one. The literature of the group, in the two decades since the appearance of Thom's *The Penicillia*, has increased by leaps and bounds, and entirely new areas of investigation have been developed. The time was ripe, therefore, for a summation of our modern knowledge of *Penicillium*, and in Raper and Thom's book we have this need abundantly fulfilled.

After a short Preface there is a section entitled General Discussion, covering such topics as a historical discussion of the Penicillia, the generic diagnosis and synonymy of *Penicillium*, methods of observation, techniques employed, and features of structural and biological significance in describing species. This last section is unusually comprehensive, meticulously executed, and excellently illustrated. The fourth chapter of this section deals with the cultivation and modern methods of preservation of the Penicillia. The section concludes with a superb account of the history of penicillin and the methods employed in its commercial production.

Part II, the Manual Proper, opens with a chapter on the use of the manual. Here are described in careful detail such topics as the data necessary for identification (a sample data sheet being included), bases for classification, series, species, varieties, mutants, strains, etc. Since the 137 species recognized in this manual as valid cannot be effectively handled in a single key, species series are utilized in both the Diagrammatic and General Keys for Identification which are included. Once the series is known, a Series Key guides the investigator to the proper species. Under each Series is given a synopsis of outstanding characters, the Series

Key and a discussion of the Series as a whole. The species descriptions include citations, synonyms, comments, and numerous illustrations, both of colonies and of particular structures of importance in identification. Ten plates in full color greatly enhance the descriptions of the colonies. The final chapter of this section deals with *Gliocladium*, *Paecilomyces*, and *Scopulariopsis*, genera closely allied to *Penicillium*. These are treated in the same manner as *Penicillium*.

Part III is given over to reference material. It contains a comprehensive topical bibliography, with items ranging from acid formation, allergy and antibiotics, through deterioration, pathogenicity, and penicillin, to tannins. Other topics are also considered. This is followed by a general bibliography. After a species index and index to accepted species and varieties, a 24-page general index concludes the volume. Throughout are excellent illustrations by Dorothy I. Fennel. On the whole, the book is well made and printed, although a few instances of imperfectly printed and inky pages occur in the reviewer's copy. Typographical errors are remarkably few.

It seems almost needless to add that Raper and Thom's book is a star of the first magnitude which will unquestionably take its place in an American mycological firmament.

F. K. SPARROW

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MARIN FLORA. *Manual of the Flowering Plants and Ferns of Marin County, California.*

By John Thomas Howell; photographs by Charles T. Townsend. University of California Press, Berkeley and Los Angeles, California. $4.50. vii + 323 pp. + 25 plates; text ill. 1949.

Marin County, California, lies just north of the Golden Gate, and comprises 529 square miles of country that, in spite of its nearness to a great metropolitan center, has maintained a surprising amount of its natural vegetation. The topography is hilly or mountainous, and large towns have not developed. Within the county are such tourist attractions as Mt. Tamalpais and Muir Woods. The main part of Howell's book is devoted to a manual of the flora of the county. At the beginning is a key to the principal groups of families, and then keys to the families within the groups. Keys to genera and species are given within the treatments of the various families. Separate descriptions of species are omitted, but there are copious notes on habitat and local occurrence. Synonymy is limited to essentials, and common names are not belabored. There are 1313 species and 144 named varieties and forms included in the manual.

A rather long introduction describes the physiographic features of Marin County, its geology, soils, and climate, and its principal life zones and plant associations, along with a numerical analysis of the flora, and sections on geographic relationships. The introduction closes with an account of botanical exploration. The book is illustrated with 25 superbly executed half-tone plates illustrating the botanical landscapes of the region. A list of references, a glossary, and an index to common and scientific names are appended. Howell's manual has a place in the library of every student of western North American floras. It is scholarly, carefully documented, and finely printed.

H. M. RAUP

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OBSERVACIONES SOBRE LA VEGETACIÓN DE LA PROVINCIA DE TUCUMÁN. *Monogr. Inst. Estud. Geog.*, 5.

By Jorge Hieronymus; revised and with notes by Hans Seckt. Instituto de Estudios Geográficos, Facultad de Filosofía y Letras, Universidad Nacional de Tucumán, Argentina. (Paper). 162 pp. + 1 map. 1945.

This is a reissue of an early but classical account of the vegetation of the small Argentine province of Tucumán. The original account, published in 1874 in the *Boletín de la Academia Nacional de Ciencias de Córdoba* (Argentina), is rare, a copy not even being owned by the library of the Córdoba institution where it was published. Since this work is still considered basic to the student of the vegetation of that part of Argentina, it has been republished. Seckt, of the National University of Córdoba, has clarified somewhat the heavy "Germanic" style used by Hieronymus in the original and has also appended important nomenclatorial changes where necessary. The phytogeographical account of Hieronymus is a descriptive one in the classical style, and follows in general the pioneer vegetational work of Grisebach (1872) so popular at the time. Hieronymus lumps his plant "formations" into 5 general types (chapter headings) which, though perhaps not now acceptable, may be correlated with the phytogeographical regions recognized in the province today. Besides its importance as a pioneer work, Hieronymus' account should be of much value to the Argentine ecologist who is seeking a clue to original types of vegetation in a province the native plant species of which have often been replaced by intensive agriculture.

W. H. HODGE

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TREES OF THE COUNTRYSIDE.

By Margaret McKenny; illustrated with lithographs by Alice Bird. Alfred A. Knopf, New York. $2.50. vi + 63 pp. + 32 plates; text ill. 1942.

This is a slender volume on some of our common trees, written from an appreciative rather than a scientific point of view. The accompanying lithographs by Alice Bird provide the necessary support for brief descriptions.

PLANT MORPHOLOGY

PLANT PATHOLOGY.

By Sir Edwin J. Butler and S. G. Jones. The Macmillan Co., New York (printed in Great Britain). $10.00. xii + 979 pp.; ill. 1949.

The first third of this book is about general principles of plant pathology, and the last two-thirds describes representative specific diseases of plants. The section on principles is, in general, excellent. It is difficult to present logically in 330 pages all of the interrelated factors of host, parasite, and environment that lead to disease, but the authors have succeeded remarkably well. The nature of disease organisms and their life histories, the host-pathogen relationship and the nature of resistance, the influence of environment, pathological anatomy and histology, and disease control are covered with apparently few significant details omitted. Most of the examples given are of fungus disease, with a few references to those caused by bacteria. There are special chapters on virus and deficiency diseases, which seems desirable in view of their unique nature. There is also a brief classification of the fungi. Chapter 2 contains sections on the persistence of parasites from year to year, variation and specialization in fungi, and epidemics. It might have been more logical to put the discussion of variation and specialization with the chapter on resistance and susceptibility. The section on epidemics is largely historical and descriptive, and one feels a need for a summary section describing the way in which various factors contribute to the occurrence of epidemics.

Over 160 specific diseases are discussed in Part II, Selected Diseases. These are well chosen and for the most part adequately treated. The discussions are brief but complete, and detailed information is given when such detail is available and based on extensive research.

The book is well written and readable. Direct reference to authorities in the text is infrequent, which adds to its readability, but the reader may not like to turn to the references to know the names of contributors. The book was completed in 1943, and most of the literature cited dates before that; although there are some more recent references, more could have been used.

A student who has read and comprehended this book should have about as good an education in plant pathology as one can get by reading. It is probable, however, that a beginner may not appreciate some of the many excellencies of viewpoint and judgment shown here until he has had broader experience. The book, therefore, will bear repeated reading by students, and will do much to orient and clarify the information of more experienced plant pathologists. It will also be found highly useful to many people other than plant pathologists, whether they wish to get quick information about a specific disease or to acquire a sound background in general plant pathology.

CARL J. EIDE

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BITS THAT GROW BIG. *Where Plants Come From.*

By Irma E. Webber. William R. Scott, New York. $1.50. 64 pp.; ill. 1949.

A simple and effectively written and illustrated child's book on plant reproduction, covering seeds, tubers, spores, cuttings, etc. Easy-to-do experiments accompany the text to enable the youngster to see for him self or herself the manner by which plants grow and develop.

PLANT PHYSIOLOGY

PRAKTIKUM DER ZELL UND GEWEBEPHYSIOLOGIE DER PFLANZE. *Pflanzenphysiologische Praktika, Vol. II. Second Edition.*

By Siegfried Strugger. Springer-Verlag, Berlin, Göttingen, and Heidelberg. DM 27.60 (cloth); DM 24.00 (paper). viii + 225 pp.; ill. 1949.

In his new edition Strugger has produced an improved laboratory manual of cell and tissue physiology of plants. This book, already known to many American scientists, has been completely reorganized to include a number of subjects not treated in the first edition or in any other manual. It is the only book that covers adequately the subject of cell physiology as it has been developed in Strugger's laboratory. An English translation would be an important contribution to our botanical literature.

The subject matter, presented as individual experiments, is organized under 7 topics. First is the preparation of living cells and tissues, in which directions are given for the study of cells in both natural and artificial media. Second, microscopic studies of living plant cells and tissues are described. Included are analyses under light field, dark field, the fluorescence, and the phase contrast microscopes. The apparatus for each of these types of study is described. Next come cytomorphology and experimental cytology, making use of the techniques described in the first 2 chapters. Such phenomena as protoplasmic streaming, the outflow of protoplasm from cut cells, changes in viscosity, and plasmoptysis are covered. The nature of the cell nucleus under many experimental conditions is pictured. Chloroplasts and chromoplasts have been given detailed studies, using many reagents. Finally, the vacuole system of plant cells is described in many experimental phases. The chapter on plasmolytic methods has been brought up to date, but no important concepts have been changed. Quantitative methods for determining osmotic pressure by plasmolysis are presented in considerable detail. Chapter 5 describes experiments on absorption. The effects of various ions on plasmolysis forms are given. Vital staining, wound stimulation, and plasmolyzability are treated. Permeability studies of many types are described, and directions for laboratory experimentation are stated clearly. Using both light field and fluorescence microscopy, Strugger pictures the uptake of acid, neutral, and alkaline vital stains. The selective staining of many plant structures is described and illustrated. Not only are the methods given, but the theoretical significance of vital staining is treated in several places.

The book ends with 2 new short chapters, one on electrocytology and electrohistology as determined by treatment with dyes at various pH, the other on the transport of materials in plants. Translocation is broken up into cell-to-cell movement, transport through the xylem tissues, and movement in the phloem. Many of the experiments on translocation involve new dyes which serve as tracers. Though some of these are introduced into cut stems, others, such as K-fluorescein, are apparently absorbed through living cells and translocated through the phloem of relatively intact plants. This type of indicator is of the type long sought by physiologists to aid in translocation studies. While experiments to date have not clarified all of the problems in the translocation of food materials within the plant, they give more critical data than many of the older tracers. They should aid materially in the ultimate solution of many of these problems. This book may be highly recommended to all who are interested in the detailed study of the cellular physiology of plants.

A. S. Crafts & H. B. Currier

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La Physiologie Végétale. *"Que Sais-Je?" Le Point des Connaissances Actuelles.*

By Raoul Combes. Presses Universitaires de France, Paris. 76 fr. (paper). 128 pp.; ill. 1948.

Previous numbers in this series have dealt with everything from the *History of Africa* to *Radiation and Life*, and the series seems to be designed to provide the intelligent layman with an appreciation of the basic facts, methods, and generalizations of the most various subjects. In general, Combes has succeeded in highlighting the fundamental characteristics of the living plant and the problems posed by it, and has done so in a reasonably entertaining manner. The major topics considered are: (1) the incorporation of various substances into the living plant body; (2) metabolism; and (3) the energy relations of the plant. The historical account of the discovery of the basic facts about plant nutrition is well done, even if contributions of French investigators are slightly overemphasized. However, many important and interesting aspects of developmental plant physiology are completely disregarded, and other topics (such as respiration, plant hormones, and enzymes) do not receive sufficiently modern treatment. There are no references, the illustrations are few, and the emphasis of chapters is sometimes ill-placed. Despite these failings, the author has succeeded in cooking a reasonably palatable dish of "plant science for the citizen." Publishers of pocket-sized books in this country might well consider the production of a similar but somewhat improved volume in English.

Arthur W. Galston

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Elementary Plant Physiology. Laboratory Manual.

By Stuart Dunn. Addison-Wesley Press, Cambridge, Mass. (1) $3.50; (2) $1.00. (1) v + 164 pp. 1949.

The 9 chapters of this brief book cover the plant cell, absorption, transpiration and translocation, mineral nutrition, photosynthesis, organic constituents, respiration, and growth. These chapters give the impression that not much new work has been done in plant physiology during the last 10 or 15 years. With few exceptions the literature cited dates before 1940. There are general reading lists at the end of each chapter, but no mention is made of several textbooks of plant physiology that are in use today.

The chapters on transpiration and translocation, mineral nutrition, photosynthesis, and growth are adequately done from a historical point of view. The chapters on organic constituents and respiration, the very heart of plant physiology, are sketchy, the work of Thimann, Goddard, J. Bonner, James, and others in these fields not being mentioned. The subject of enzymes is treated briefly, and it is interesting to learn that the author does not believe that any enzymes have yet been crystallized.

The author has prepared a laboratory manual to accompany the text. The experiments are standard in most elementary physiological laboratories and follow the subject matter of the book.

G. R. Noggle

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ECONOMIC BOTANY

La Sélection Végétale. *"Que Sais-Je?" Le Point des Connaissances Actuelles, No. 219.*

By Germain Chalaud. Presses Universitaires de France, Paris. 75 fr. (paper). 128 pp.; ill. 1946.

This little book is a popular exposition of the principles and procedures of plant breeding (not of natural selection). It is divided into 5 chapters. The first outlines the scientific basis of selection or the laws of genetics. The second is concerned with "conservative" selection and defines the methods employed to perpetuate and propagate desirable varieties. The third considers "creative" selection through hybridization, which produces new characters by crosses between varieties. The fourth reviews the more complex situation in interspecific and intergeneric crosses. The fifth describes mutations and polyploidy. Chalaud writes clearly and convincingly. He uses scientific vocabulary unapologetically, as French popular science writers can with a considerable measure of impunity, because of the average man's relatively extensive vocabulary and feeling for words. For the same reason, it is found possible to do with very few pictures (only 9). The logical presentation of the subject, with reference to familiar examples, makes excellent reading for the layman, but the book will hardly be found to suit the requirements of the practical agriculturist.

The references cited are all French: some of them are rather inaccessible and two or three either obsolete or unreliable. Mention is made in the text of American, Canadian, and Russian work, but very little of it is described. On the other hand, many interesting histories of French plant breeding are given. These will be of considerable interest to the American student who is already versed in the subject and familiar with similar cases under quite different environmental conditions.

PIERRE DANSEREAU

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CHILD'S GARDEN OF FLOWERS.
CHILD'S GARDEN OF VEGETABLES.

By Robert V. Masters. Greenberg, New York. $1.00 each. 32 pp. each; ill. 1949.

Here is a clever idea, sure to appeal to the very young gardener—little books with simple directions, and with 5 packages of flower or vegetable seeds pasted right beside the appropriate descriptions. But be sure you get *this* year's edition, since old seeds, in spite of the 3-year guarantee, might bring disillusion. The pictures will help to tell the weeds from the flowers as they are growing up.

BENTLEY GLASS

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AMERICA'S CROP HERITAGE. *The History of Foreign Plant Introduction by the Federal Government.*

By Nelson Klose. The Iowa State College Press, Ames. $3.50. x + 156 pp.; ill. 1950.

America's Crop Heritage, in presenting the history of foreign plant introduction, is of interest to all botanists and agriculturists. In addition, it should be of value to students of economic history, as it fills a gap in the story of the economic development of the Nation. It also outlines the process of cultural transference and reveals America's debt to other countries.

Plant introduction has been necessary from the outset, since only a small proportion of our crop plants are native to the United States. The first 2 chapters deal with the Colonial Period and the early days of the Nation from 1770 to 1840. This was a time when government played little or no part in promoting agriculture, and the search for new plants was largely in the hands of individuals and agricultural societies. The third chapter is concerned with the first attempts by the Federal Government to aid in the introduction and growing of crops, and stresses particularly the work of the Wilkes, Perry, and other exploring expeditions.

In 1839, the Agricultural Division of the Patent Office was organized. Until 1862 it was the leader in the collection and distribution of seeds to the farmers of the country. Tea and sorghum were the principal new introductions during this period.

In 1862, a Department of Agriculture, headed by a Commissioner, was established. Several chapters are devoted to its varied activities. A great advance was made in agricultural education, and a beginning in the selection and breeding of new varieties of native wheats and the development of native grapes. Many important crop plants, such as the durum wheats, Egyptian cotton, jute, ramie, sugar beets, oranges, eucalyptus, and several forage grasses were introduced. In 1889, the first Secretary of Agriculture was appointed and given Cabinet rank. The great advances made under Secretaries Rusk, Morton, and James Wilson, and the even more spectacular progress made under their successors in the 20th Century, are outlined in the 3 final chapters. Of special interest is the account of the organization of the Bureau of Plant Industry, the work of the Office of Seed and Plant Introduction, and the activities of "special agents" or agricultural explorers, such men as Fairchild, Hansen, Carleton, Knapp, and Meyer. Among the many new introductions may be mentioned those of dates, figs, soybeans, and tung trees. Four official documents relating to the early days of plant introduction are given in an appendix.

ALBERT F. HILL

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GUIDE TO THE MEDICINAL AND POISONOUS PLANTS OF QUEENSLAND. *Coun. Sci. Indust. Res. Bull. No. 232.*

By L. J. Webb. Council for Scientific and Industrial Research, Melbourne. Free upon request (paper). 202 pp. 1948.

In the introduction of this bulletin the author has included a discussion of some historical aspects of botanical exploration carried on in Australia. In addition, he has told something of certain writings which deal with the chemistry and pharmacology of poisonous and medicinal plants, particularly those of Queensland. The need for much additional work on the chemistry and pharmacology of the plants is brought out. The various plant species have been arranged alphabetically by families, with the genera also in alphabetical order. With limited space, the amount of information concerning the medicinal and poisonous properties of any particular species is necessarily limited in most cases. Native, as well as non-indigenous plants of Queensland are included. The value of this publication is enhanced by the numerous sources of information cited. Many references are listed alphabetically by author. A well-prepared index to botanical and popular names is included on the last 18 pages of the bulletin. Workers interested in certain economic phases of botany, in plant chemistry, and in the pharmacology of plant constituents, should find this bulletin useful.

MAYNARD W. QUIMBY

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VEGETABLE GUMS AND RESINS. *A New Series of Plant Science Books, Vol. 20.*

By F. N. Howes. Chronica Botanica Co., Waltham, Mass.; Stechert-Hafner, New York. $5.00. xxii + 188 pp.; ill. 1949.

The pages of this interesting and useful monograph are permeated with faint echoes of romance and adventure. To read of frankincense, myrrh, Chinese lacquers, and dammar is to be transported in time and space to a world far removed from the swift tempo and relentless pressure of modern life. The trade in gums and resins is as old as civilization itself, and the story is well worth the telling. Howes has assembled his material skillfully, so that a great deal of information about this ancient trade is compressed within a volume of modest dimensions.

The book is divided into two parts: the first deals with the gums, and the second treats the resins and their derivatives. A brief discussion of the physical and chemical properties of the subject matter introduces each division of the book. The interests of the author are strictly botanical, and this is made abundantly clear by the very limited attention given to chemical and physiological aspects of the subject. The importance of each of the many commercial gums is discussed, with reference to its place in historical and modern trade practices. The distribution of the gum-yielding species is outlined, and the botanical characteristics of these plants are described. A section is included on the methods employed in tapping the plants and collecting the gums. This is usually followed by a description of the quality factors which determine the various market grades and a list of the ways in which the gums are utilized in industry. A similar procedure is followed in the treatment of the resins. Helpful indexes to scientific and common names of plants and products referred to complete the volume. The monograph fills a useful place in botanical literature. A great deal of information has been gathered together from scattered sources and here made readily accessible to the reader in simple and direct prose. Numerous line drawings of the vegetative and reproductive structures of the important species of resin and gum-producing plants enhance the attractiveness of the book. Howes' book will be particularly helpful to economic botanists, but its appeal is by no means restricted to those interested in this phase of the science. The many interesting facts and observations contained within its pages make it a useful reference work for all who have a professional interest in plants and their products.

DONALD B. ANDERSON

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THE NATIVE FORESTS OF CUYAHOGA COUNTY, OHIO. *The Holden Arboretum, Bull. No. 1. Sci. Pub. Cleveland Mus. Nat. Hist. Vol. IX.*

By Arthur B. Williams. Cleveland Museum of Natural History, Cleveland. $1.00 (paper). 90 pp.; ill. 1949.

This description of the probable composition and distribution of the native forests of Cuyahoga County, Ohio, is based on the observations and historical researches of a botanist who has been actively engaged in the study of the native flora of this county for the past 18 years. The small northern Ohio county is of special ecological interest because of its environmental variability. Within its boundaries two great continental physiographic provinces (The Appalachian Plateaus and the Central Lowlands) meet. This situation, coupled with a climate transitional between that of the east coast and the continental interior, has resulted in markedly diverse environmental backgrounds adaptable to a number of different plant communities. Characteristically eastern, western, northern, and southern plant associations are all represented in the area. Their present and probable presettlement status are discussed in some detail by the author. The bulletin is illustrated with a number of good halftones depicting views of current examples of the various forest communities, plus individual relict trees of the original forest which, during the past 150 years, have somehow escaped the woodsman's axe. A check list of native and introduced trees, with special remarks about their natural distribution and local occurrence, is presented at the end of the discussion. With reference to the exotics, one misstatement occurs: *Pinus nigra* is said to be "the dominant species in the 'Black Forest' of Germany" whereas, in fact, it is of little or no importance in that area.

SCOTT S. PAULEY

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BETTER DOUGLAS FIR FORESTS FROM BETTER SEED. *Agnes H. Henderson Research Publications.*

By Leo A. Isaac. University of Washington Press, *Seattle.* $1.00. xii + 65 pp.; ill.; two map enclosures. 1949.

Consideration is given in this publication to the comparative development in plantations of Douglas fir (*Pseudotsuga taxifolia*) grown from seeds from different geographic sources and representing strains or site races influenced by rainfall, temperature, elevation, latitude, and various environmental factors. The results of the study give rise to recommendations for forest planting, namely, that the seed source and the planting site should be well matched with respect to the several environmental factors affecting tree growth. The existence of site races and the adaptation of such strains to a rather narrow range of certain environmental conditions is proved by growing trees from seed from a number of different localities within the natural range of the species. Similar results were obtained both in this country and in Europe. Among suggested rules concerning seed procurement for reforestation with Douglas fir are limits as to the distance north or south of a planting site, limits of variation in elevation, similarity of mean temperature and frost-free periods, as well as indications of good health and suitable form of the seed trees. Superior natural strains of Douglas fir have been recognized which should be sought as seed sources within given areas. The superior strains will supply basic material for further genetic improvement through selection and hybridization. In the meantime, a system of seed certification is needed to promote development of the better strains for appropriate sites and thus assure greater success in reforestation. Evidently the standard of measurement for superior strains is rapidity of growth, coupled with desirable tree form and branching habits. A few localities reported to yield superior strains are mentioned.

BENSON H. PAUL

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TEXTBOOK OF WOOD TECHNOLOGY. *Structure, Identification, Defects, and Uses of the Commercial Woods of the United States. Amer. Forestry Ser., Vol. I.*

By H. P. Brown, A. J. Panshin and C. C. Forsaith. McGraw-Hill Book Co., New York, Toronto and London. $6.00. xxviii + 652 pp.; ill. 1949.

This volume is essentially a new edition of *Commercial Timbers of the United States* (1940), by Brown and Panshin. It is characterized by its broad scope, its keys, glossary, and the excellence of the photomicrographs. Significant changes in the new book are adoption of the International Code of Nomenclature, revision of the section dealing with the walls of xylary cells, addition of a third key to the identification of coniferous woods, and a more extensive citation of literature.

I. W. BAILEY

DISEASES OF POTATOES, SUGAR BEET AND LEGUMES.

By W. A. R. Dillon Weston; illustrated by Ann Murray. Longmans, Green and Co., London, New York, and Toronto. 4s. (paper). viii + 86 pp.; ill. 1948.

This is a companion volume to two similar, popular booklets by the same author, viz., *Diseases of Cereals* and *Diseases and Insect Pests of Vegetables.* The important diseases of potatoes, sugar beets, mangels, beans, peas, clover, and alfalfa occurring in Great Britain are described in a popular, readable, but authoritative style. Drawings by Ann Murray serve to illustrate the life history and symptoms of the diseases in a clear, interesting manner. Some 11 diseases of potatoes and 9 diseases of sugar beets are described, but only a few diseases of any of the legume crops are mentioned. The material presented should be useful to the cultivator in Great Britain. It is informative to the layman in any country, since many of the diseases described are common to agricultural areas of temperate climates. The features of most general interest are the sections devoted to the history of the potato and to a vivid account of the Irish potato famine of 1845–46. The late blight disease, which destroyed the potato crop of Ireland in those years, still serves as the most classical example of the effect of plant disease epidemics on human welfare.

J. H. MARTIN

GENERAL AND SYSTEMATIC ZOOLOGY

ATLANTIC REEF CORALS. *A Handbook of the Common Reef and Shallow Water Corals of Bermuda, Florida, The West Indies and Brazil.*

By F. G. Walton Smith; photographs by Frederick M. Bayer. University of Miami Press, Miami. $3.75. 112 pp. + 41 plates; text ill. 1948.

This attractive, readable handbook should prove extremely useful to all those interested in corals, whether amateur collectors or professional students of marine life. A most impressive feature is the magnificent set of over 40 full-page photographic plates taken by Frederick Bayer of the United States National Museum. They undoubtedly constitute the most superb collection of photographs of corals ever published and will appeal fully as much to all lovers of design as to collectors and biologists.

The text gives a clear and informative general account of corals and coral reefs in non-technical language. Included are competent although not extensive presentations of the various theories of coral reef and atoll formation, the structure, habits, and life history of corals, and methods of collection and preservation.

Each species is described both in technical and nontechnical terms and its distribution given as to Bermuda, Brazil, Florida, the West Indies, and the Bahamas. There are two keys, one based on the dead skeletons, and one, more technical, on both skeletal and other anatomical traits. There is a glossary and a bibliography. A future printing would be more useful with an index.

Gairdner B. Moment

Sea Anemones and Corals of Beaufort, North Carolina.

By Louise Randall Field. Duke University Press, Durham, North Carolina. $2.00 (paper). 39 pp.; ill. 1949.

Fourteen species of anthozoans (2 horny corals, 1 stony coral, 1 pennatulacean, 9 sea anemones, including 1 new species, and 1 ceriantharian) collected at Beaufort are described and figured.

A Textbook of Entomology.

By Herbert H. Ross. John Wiley & Sons, New York; Chapman & Hall, London. $6.00. x + 532 pp.; ill. 1948.

The subject matter of entomology is rapidly growing away from the purely taxonomic approach which has been so common since the days of the classical textbooks of entomology. The title of this book is appropriate, but one should not expect to find the detailed systematics of the older books or of some more recent but less modern volumes having a similar title. This book does not emphasize any one approach to the subject, such as the physiological, economic, public health, systematic ecological or morphological, but rather is an excellent endeavor to give and integrate the necessary points of all of them for the insects. The first chapter covers the history of entomology up to the present day; it is followed by a comparative account of the general structures of the Arthropoda in the second chapter. The external and internal anatomy of the insects in a generalized fashion are considered next (2 chapters). With this foundation it has been possible to consider separately in the chapter on Physiology the functions of the organs and tissues previously described. A phase of entomology nearly omitted in entomological curricula as well as in standard zoological courses in the subject (yet here considered) is embryology; even so, a biologist will feel that the treatment is too scanty. Experimental methods are not touched upon. Orders of Insects, a taxonomic treatment, is the largest chapter in the book. The author's attempt to decrease the comparative-morphological and taxonomic aspects of the book has meant that only the larger taxonomic groups find a place; perhaps if this section were more detailed and set in smaller type, the student would not find it so often necessary to refer to other textbooks or reference manuals for the identification of insect groups. Coverage of insect paleontology occupies the ninth chapter; this field is a nearly neglected one in modern entomology and the author is to be commended for bringing the field into greater prominence. Ecological Approaches to Entomology (Chapter 10) is followed by the last chapter, Control Considerations, which leaves the impression that this is the purpose for which insects are studied. The book is the most rounded textbook on the subject published in recent years, but, like many college textbooks, it is written *about* a subject rather than *of* a subject. Experimental approaches to entomology, such as genetics, are not considered. Nevertheless, this book will be of indispensable value for college courses where a minimum of reference material is desired and a broad approach to the field of entomology is thought to be more important.

W. Hovanitz

Nearctic Helina Robineau-Desvoidy (Diptera, Muscidae). *Bulletin Amer. Mus. Nat. Hist. Vol. 94: Art. 3.*

By Fred M. Snyder. American Museum of Natural History, New York. 65 cents (paper). Pp. 107–160. 1949.

A revision of the genus *Helina* of the Mydaeini, with a key and descriptions of 53 species, 11 of them new and 1 renamed.

Coléoptères Scarabéides *De l'Indochine. Première Partie. Faune de l'Empire Français, Volume III.*

By Renaud Paulian. Librairie Larose, Paris. 300 fr. (paper). iv + 228 pp. + 1 map; ill. 1945.

This part of the currently appearing *Fauna of the French Empire* deals with a portion of the scarabaeid beetles as they are known to occur in Indo-China. The author had for study the extensive collections of the French and British Museums. Keys for the identification of the families, subfamilies, genera, and species are given, and some 20 new species are described. The laparostict scarabs and the Dynastinae are covered in this volume; the Melolonthinae, Rutelinae, Cetoniinae, Lucanidae, and Passalidae are reserved for a second. The work is reasonably well illustrated, though the illustrations are of variable quality. The reviewer notes that Paulian has followed Schmidt's erroneous concept of the genus *Euparia*. It is probable that he has not seen the type species of this genus, which lives associated with certain ants in our extreme south.

Edward A. Chapin

Poissons Exotiques et d'Aquariums. *Atlas des Poissons—Fasc. IV. New Edition.*

By F. Angel. Éditions N. Boubée & Co., Paris. 500 fr. 163 pp. + 12 plates; text ill. 1949.

The hobby of keeping fishes in home aquaria grew greatly after the first World War. Since World War II it has become more popular than ever, not only in this country but also in Europe. The use of the small tropical fishes as laboratory animals in biological research has increased at the same time. The results of scientific experiments on aquarium fishes now appear regularly in foreign journals, as well as our own. Books describing the methods for maintaining fishes suitable for home or laboratory cultivation are keeping pace with the increased interest.

In France, Fernand Angel, an honorary assistant of the Muséum Nationale d'Histoire Naturelle, has contributed a volume to a series of popular books devoted to fishes in general (Atlas des Poissons). The fourth section of the book covers the fundamental principles of aquarium management. The introductory sections review topics concerned with the kinds of water suitable for the aquarium, the role of temperature in the different requirements of the many species of plants and animals, and some elementary physiology of respiration in fishes. The practical details of establishing a home aquarium are clearly stated, attention being given to shape and size of the aquarium, its location with reference to the source of illumination, bottom covering and the planting. Suggestions for proper management are outlined, especially those for feeding the fishes with dried and with living food. A useful, illustrated list of aquatic plants is given and their function explained. For those who keep fishes in outdoor ponds, some of the insect enemies of fishes are shown. The common diseases of aquarium fishes are described. The French adoption of the amateur's name of one of them would amuse the American aquarist; it is "Le Shimmy."

The main body of the book describes the various species of fishes which have been kept in aquaria. Many of them are not suitable for the American home aquarium, being much too large and far too rare. But these rare forms, chiefly from French colonies in Africa, are probably available to European aquarists. The description of the various species is concise, clear, and diagnostic. The black and white illustrations, if not scientifically accurate, will certainly help the reader to identify the specimens. In addition to the black and white figures, the book contains 12 color plates in which 60 species are painted in somewhat gaudy colors. Again, while these are not scientifically perfect, they do help to identify the species. Upon the whole, this book, slanted in the interests of the amateur, will be useful to French and European aquarists and to those in America who want to know what aquarium fishes are available in France.

MYRON GORDON

ORNITHOLOGIE ALS BIOLOGISCHE WISSENSCHAFT. 28 *Beiträge als Festschrift Zum 60. Geburtstag von Erwin Stresemann (November 22, 1949).*

Edited by Ernst Mayr and Ernst Schüz. Carl Winter, Heidelberg. DM 18. xiv + 291 pp. 1949.

Erwin Stresemann of Berlin is generally acknowledged to be the greatest ornithologist of our times. Biologists know him best for his great volume *Aves* in the Kükenthal-Krumbach *Handbuch der Zoologie*, which is by far the most authoritative and complete summary of information about birds. But a veritable flood of lesser works has come from Stresemann's pen, many of which have led ornithologists into new and rewarding paths or have served to link ornithology more closely with the other life sciences. Thus, his monograph on the birds of Celebes was largely responsible for the new ecological approach to the old science of zoogeography.

This collection of 28 original papers by Stresemann's students, friends, and admirers is a richly deserved tribute. Twenty-one of the papers are in German, 6 in English, and 1 in French. They run the gamut from life history, psychology, anatomy, embryology, and evolution to the history of ornithology. A. H. Miller, for example, discusses some of the ecological and morphological problems involved in the evolution of major adaptations and higher categories. Otto Koehler writes of his interesting discoveries in avian behavior. Emil Witschi outlines the utilization of egg albumen by the developing fetus. In a most interesting paper Gustav Kramer tells of a cage ingeniously devised to permit him to observe the escape movements of night migrants. He found that their efforts are usually oriented in one particular direction, though this may not coincide with the direction of normal migration.

These titles suggest the scope and originality of the contributions to this jubilee volume. Just as Stresemann's accomplishments span all of modern ornithology, so, too, this book gives a cross section of current interests in this science and its significance to other fields. For this reason alone many general biologists and all ornithologists will find it of great value.

DEAN AMADON

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THE QUAILS.

By Edward S. Spaulding; illustrated by Francis Lee Jaques. The Macmillan Co., New York. $6.50. xiv + 123 pp.; ill. 1949.

The Quails has as its purpose the presentation of accounts, convenient for the sportsman, of the quails occurring in this country. This has been done admirably. Each of the 7 species of quail that occurs within our borders is discussed in a separate chapter, which presents its description, range, life history, and comments about hunting it. A general introductory chapter precedes these accounts, and the book closes with chapters on transplanting and restocking quail ranges, and including random observations by the author. The illustrations are an outstanding accompaniment of the text, most of the quails discussed being represented by full-page color plates. In these the artist has caught the color and spirit of this intriguing and elusive group of birds.

A unique feature of the book is a chart that presents in a simplified manner the relationships of our quails to all those of the world. This is of particular interest because it proposes common names that might be useful to the sportsman for designating some of the generic groups of quails for which no common names have existed.

The author has a remarkable ability to describe personal hunting experiences and ideas in simple yet powerful language. Noteworthy is the recurrent expression of the theme that the greatest pleasure to be derived from hunting lies in mastery of this complex and difficult art, not in making large bags or in the killing of quail itself. In addition to the sportsmen for whom this book was primarily intended, it is recommended to those who are interested in problems of game management. This recommendation is made not only because of the obvious features of the book but especially because of the ease with which the author expresses the feelings that still lead men to support and pursue the art of hunting in a society as complex as ours.

John Cushing

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Tropical Birds. *From Plates by John Gould. Batsford Colour Books.*

With an Introduction and Notes on the Plates by Sacheverell Sitwell. B. T. Batsford, London, New York, Toronto, and Sydney. $2.00. iv + 12 pp. + 16 plates. 1948.

John Gould was the nearest equivalent to Audubon in Great Britain and his first volume of bird paintings was published in 1832, within a few years after Audubon's first plates. Otherwise Audubon, the artist and naturalist, had not much in common with the ornithologist and businessman Gould. Between 1832 and 1881 Gould completed 41 large folio volumes with no fewer than 2999 hand-colored plates. This incredible output was the result of collaboration between Gould, as author and publisher, and a group of artists including Mrs. Gould, Edward Lear, H. C. Richter, and William Hart.

De gustibus non est disputandum—there are many who prefer the natural simplicity of the Gould plates to the elaborate body postures of most of Audubon's birds. Being the work of several artists, the Gould plates are somewhat uneven in quality, but the best are among the loveliest of all bird portraits. Gould plates have now become collectors' items, and it will be appreciated by lovers of bird art that 16 of the most colorful bird plates, including 5 exquisite Australian parrots, are now available in excellent offset reprints. These are incomparably superior to the recently published reproductions of Audubon. The text comments by S. Sitwell are stilted and full of errors.

Ernst Mayr

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The American Trail Hound.

By Fred Streever. A. S. Barnes & Co., New York. $3.75. xviii + 202 pp.; ill. 1948.

American Sporting Dogs.

Edited by Eugene V. Connett; chapters by Gerald M. Livingston, Gladys F. Harriman, John Scofield, Robert McLean, Francis J. Squires, Arthur W. Lindsey, Chetwood Smith, Walter Roesler, Paul Bakewell, III, Prentice Talmage, David Wagstaff, Edward H. Carle, Lewis F. Gingery, Henry L. Ferguson, J. Gould Remick, Leon F. Whitney, Raymond Hoagland, William F. Brown, Edward J. Loring, Muriel W. Jarvis, Theodore A. Rehm, D. B. Ruskin, and Thomas W. Merritt; illustrated by Edwin Megargee. D. Van Nostrand Company, New York, Toronto, and London. $7.50. xiv + 549 pp. + 69 plates. 1948.

The Dachshund or Teckel. *A Complete Treatise on the History, Breeding, Training, Care and Management—With Chapters on Diseases and Their Treatment. Second Edition.*

By Herbert C. Sanborn. Orange Judd Publishing Company, New York. $4.50. xxii + 431 pp.; ill. 1949.

Such books as these are designed primarily for dog fanciers and the sporting fraternity. From a scientific point of view they may have two kinds of interest. There is usually an attempt to interpret basic scientific information to the lay public, and this may include facts relating chiefly to genetics and veterinary medicine but also to psychology and physiology. They may also include information which may be of use to scientists in indicating fundamental problems and possible experiments. For instance, geneticists may be interested in the effects of selection and inbreeding which have produced the wide variety of domestic dogs, and students of animal behavior may find indications as to the number of behavior traits associated with different breeds which are apparently inborn and how much they may be affected by training.

Streever's book, *The American Trail Hound*, makes no scientific pretensions but gives the results of his practical experience in an entertaining, anecdotal style. He also gives several pedigrees of American hound strains which might provide useful scientific information about how much inbreeding was practiced before the days of official registration.

American Sporting Dogs, edited by Connett, has 2 scientific chapters. In one, Leon F. Whitney gives a short summary on Mendelian heredity as it affects characteristics in the various sporting breeds. He also disposes of several of the common superstitions concerning animal breeding. This material is available in less condensed form in Whitney's book *How to Breed Dogs*. There is, perhaps, a tendency to overemphasize simple one-factor Mendelian heredity, particularly since many of the cases are based on limited experimental evidence, and the possibility of multiple factor inheritance is barely mentioned.

Lindsey gives a rather general discussion on the physiology of scent as it applies to hunting dogs but makes very little reference to scientific experiments on trailing. In his chapters on training and handling, Connett gives the impression that a good bird dog is made as well as born. The rest of the book is devoted to short chapters which include a brief history and the standard of physical form for each breed.

Those with special breed interests may consult more detailed works such as Sanborn's *The Dachshund*, a revised edition of a book originally published in 1937. In his scientific chapters Sanborn gives an introduction to Mendelian heredity and attempts to apply this, as far as information was available at the time of publication, to variability of form, coat, and color in the breed. This is a difficult task and again emphasizes how comparatively little genetic work has been done on the most familiar but in some ways least known of domestic animals, the dog. In his chapter on disease Sanborn gives a detailed description of symptoms of common dog diseases, together with advice based on his own experience. He is probably not as hopeful regarding the control of distemper as recent veterinary results would permit. For the rest, the book gives an excellent and scholarly history of the breed and its standards, as well as several pedigrees which indicate the type of breeding plan normally used. It would appear that dachshunds, as a general type of hunting dog, have a verifiable history as far back as the 16th Century, but that the first breed standard was not set up until 1879.

J. P. SCOTT

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DRAWING AT THE ZOO.
By Raymond Sheppard.
HOW TO DRAW FARM ANIMALS.
By C. F. Tunnicliffe. The Studio Publications, London & New York. 3s. or $1.00 each. 64 pp. each; ill. 1949; 1947.

These little books are so crammed with the superb drawings of two real masters of line and shadow in the representation of animal forms that very little space is left for the valuable hints they have to give. It scarcely matters—the biologist will prize the inexpensive books for their unforgettable pictures, mostly of mammals.

BENTLEY GLASS

BRITISH MOSQUITOES AND THEIR CONTROL. *Third Edition. Brit. Mus. Nat. Hist.—Econ. Series No. 4A. Printed by order of the Trustees of the British Museum by William Clowes and Sons, London and Beccles.* 6d. 27 pp. 1949.

FAUNAL RELATIONSHIPS OF RECENT NORTH AMERICAN RODENTS. *Misc. Pub. Mus. Zool., Univ. Mich., No. 72. By Emmet T. Hooper. University of Michigan Press, Ann Arbor.* 35 cents (paper). ii + 28 pp. 1949.

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ECONOMIC ZOOLOGY

INTRODUCTION TO APPLIED ENTOMOLOGY. *Third Edition.*
By William J. Baerg. Burgess Publishing Co., Minneapolis. $3.50 (paper). x + 191 pp.; ill. 1948.

The third edition has many improvements over the previous editions (2nd ed., *Q.R.B.*, 18: 280). The illustrations are well prepared and clear in this lithographed type of printing. Like so many other publications covering this field it is written largely to meet the problems of the author's students. In general, the work treats the economic pests on the basis of their taxonomic arrangement. It begins with an account of the phylum Arthropoda and then discusses the various classes beginning with the Arachnida. The accounts are very brief and entirely restricted to those forms that are injurious or in some measure beneficial to man. Under the insects there is a brief chapter on their structure, their general biology, and as in all such textbooks a summary of the financial losses due to their activities. No indication is given here as to the vital importance of insects in present-day agriculture. A rather full account is given of the new and modern insecticides, and a brief account of biological control is appended. The accounts of the various pests discussed are well prepared and directions for their control are outlined. Various references are given under each order, and there is a general bibliography (very brief and incomplete) at the beginning of the work.

ROBERT MATHESON

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PESTS OF FARM CROPS. *Agricultural Series.*
By J. H. Stapley. Farmer & Stock-Breeder, London; E. & F. N. Spon, London. 21s. viii + 325 pp. + 19 plates; text ill. 1949.

This book on practical entomology, written by an advisory officer in eastern England, covers insects, nematodes, and other small animals that attack growing crops. The major part of the work is arranged by taxonomy of the pest, but the author has an extended listing by crops and by parts of the plant affected. He leans more heavily than most on the manipulation of environment as a control measure. This is a good practical treatise of direct use to the farmer.

JAMES G. HORSFALL

ANIMAL GROWTH AND DEVELOPMENT

MECHANISCHE GENWIRKUNGEN. *Funktionsentwicklung I.*

By Erich Blechschmidt. Musterschmidt KG. Wissenschaftlicher Verlag, Göttingen. DM 24.00. xii + 204 pp.; ill. 1948.

A reader expecting to find information on genic action in this book will be disappointed. Genes are mentioned only occasionally and perfunctorily, and have no bearing on the author's theory. The book actually deals with embryology and sets forth a theory of development which claims to solve a great many and ultimately all problems of morphogenesis. The theory is based exclusively on morphological observation of stained and fixed material from human embryos. The author intentionally uses only the morphological approach to embryology and appeals for his procedure to the method of Wilhelm His, to whose memory the book is dedicated. He expressly rejects the experimental and the comparative approaches and all conclusions derived from them. It is curious to note, therefore, that "experimental" thinking is actually used occaionally, e.g., when the author compares well and badly fixed preparations of lung primordia, in order to provide evidence for their actual state of hydration in vivo.

The book makes hard reading mainly because of the author's awkward style and a large number of typographical errors. Particularly disturbing is the author's tendency to use well-established technical terms, such as induction, determination, synapse, in a different meaning from those customary in biology.

The book's thesis, on the other hand, is fundamentally simple and plausible. The author points to the fact that embryonic epithelia have a different function from adult ones, since they always form membranes between an outer fluid on one side, such as the amniotic fluid or the liquid contents of internal organs, and the mesenchyma, with its more or less fluid ground substance, on the other side. The epithelium controls the exchange of "submicroscopic particles," particularly water molecules, between the two fluids. The epithelia (called "diathelia" in this connection) are therefore said to control a "diathelial metabolic field." It is assumed that different epithelia are different in the amount and direction of their secretory activity. The water used for secretion to the outside is assumed to be removed from the underlying mesenchyma, which becomes in consequence relatively dehydrated, and appears as a denser connective tissue. Furthermore, the arrangement of different epithelia and their differential activity gives rise to mechanical stresses, which are thought to be responsible for the arrangement of the mesenchyma in definite patterns that finally lead to organ formation. Morphogenesis is interpreted exclusively in terms of mechanical stresses arising through the activity of the epithelium. This principle is carried through for a large number of specific embryological processes, and anatomical facts like the arrangement of muscles in the limb and the particular arrangement of nerve fibers, both inside the central nervous system and in the periphery, are "explained" in this way. Chemical factors are assumed to be active only in the primary phase, i.e., the "diathelial" field.

While it is perfectly plausible to assume that the situations postulated in the theory do exist and that they may influence morphogenetic patterns, it appears unlikely that the wide generalization given to them by the author corresponds to the facts. Here, as elsewhere, no definite conclusions can be drawn from morphological description alone, and the experimental tests appear highly desirable.

This review would be incomplete without calling attention to the large number of excellent illustrations. The microphotographs are very distinct, and well reproduced. In addition, there is a large number of clear diagrams, drawn in pen and ink, which may be well worth the attention of students of anatomy and embryology.

ERNST CASPARI

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THE PRE-EGG STAGE IN BULLER'S MOLLYMAWK. *Biological Monographs, Number 2.*

By L. E. Richdale, 23 Skibo Street, Kew, Dunedin, S.W.1, New Zealand. Otago Daily Times & Witness Newspapers Co., Dunedin. 10s. from agents; 7s 6d. from author direct (paper). 50 pp. + 8 plates; text ill. 1949.

A 7-week sojourn on the Snares Islands (south of Stewart Island, New Zealand) was made by the author and a friend to study the pre-egg laying behavior of Buller's mollymawk (a species of albatross), *Diomedea bulleri*. A total of 346 nests was observed and 161 birds were banded. From these observations it was found that the males arrived at the islands on the average earlier than the females. The males awaited the arrival of the females, at which time coition occurred. Both sexes were frequently absent from the nest site until the day before the egg was laid, at which time the females returned, whereas the males did not return to the site until about a day after the egg laying. This is interpreted as indicating that two drives influence the behavior of the male: a coitional urge that impels him to await the arrival of the females; an urge to absence at the time of egg-laying preparatory to taking his first turn on the egg. Although a highly spectacular precoitional ceremony occurs, the writer does not believe that the cycles of both males and females must be attuned, as the males are apparently always ready to participate. Intruder males often successfully force coition on females not their permanent mates. Territorial defense plays a minor role, as trespassing is not common. The writer is also convinced that among these birds recognition of each other's sex is by sight rather than by any behavioral attitudes such as those usually attributed to nondimorphic species of birds. This valuable contribution, in addition to a list of cited references, is illustrated and has an index and some appendices. The latter describe in detail some of the more significant behavioral activities of the mollymawks.

HENRI C. SEIBERT

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DYING, APPARENT-DEATH AND RESUSCITATION.

By S. Jellinek. A William Wood Book, The Williams and Wilkins Co., Baltimore. $3.50. viii + 263 pp. 1947.

It is strange that the literature of medical science, concerned as it is with the staying of death, has so little to say on the subject of death itself. This fascinating book is an attempt to remedy that deficiency. The work of a former professor of electrophysiology at the University of Vienna, the book is the fruit of more than 40 years of study, observation, and experiment on death and apparent death. The author firmly believes that dying and death are far more complex than is often supposed, that death is not easy to diagnose, and that thorough examination of newly "dead" bodies will not infrequently reveal signs of life that may be resuscitated. He feels that carelessness on the part of physicians in examining the dead has been responsible for many deaths that might have been prevented.

Since the book is intended primarily for medical students and practitioners, a large part of it is devoted to a detailed study of the death-process in age, disease, and shock. One of the most interesting chapters deals with the role of psychic factors in the last moments of life. In this section also the author pleads for more frequent autopsies, in order that more may be learned about the immediate and decisive changes that end life. The second half of the book deals with the techniques of resuscitation. The author vigorously condemns the popular life-saving methods as being lethal in themselves, and recommends instead methods which totally avoid compression of the chest. This portion of the book should be read by all who may be called upon to administer artificial respiration.

Well-written and easy to read, the volume is richly illustrated with examples from the author's own experience. Though the reasoning is occasionally uncritical, the pages are packed with important ideas and information. The book should not be missed by any student of medicine.

FLORENCE MOOG

ANIMAL MORPHOLOGY

LE MIMÉTISME ANIMAL.

By Robert Hardouin, with preface by Etienne Oehmichen. Presses Universitaires de France, Paris. 280 fr. (paper). 221 pp.; ill. 1946.

LE MIMÉTISME: *Colorations Animales, Dissimulation des Formes et Déguisements, Ressemblances Mimétiques. Bibliothèque Scientifique.*

By Lucien Chopard. Payot, Paris. 930 fr. (paper). 335 pp.; ill. 1949.

The subject of mimicry, especially among the insects, is a fascinating one, possibly because there are no limits to the amount of imagination that is permissible. Anyone has the privilege of seeing resemblances wherever he may find them and of fashioning theories as to their importance in the economy of the so-called mimic. For centuries man has seen that certain animals resemble more or less closely certain other animals, or parts of plants, or parts of their own environments. But as yet no explanation has been made as to how this has come about, and no theory has been proposed as to why it has come about that is acceptable to all students of the subject.

Hardouin's book appears to be a rather uncritical exposition of the classical approach to the subject. The author passes over most of the damaging objections that have been raised against the theories of mimetic coloration and form. It does not appear to be an important contribution to the subject, either pro or con.

In the introduction to his treatise, Chopard first apologizes for the use of the term "mimicry." He writes that of course the word must not carry any idea of voluntary imitation but that it is more convenient to talk of "mimicry" than of "special procryptic resemblance."

The work is divided into two parts: in the first are the verifiable facts which have been recorded concerning homochromatism (concealing coloration) and homotypism (concealing form). The first of these often occurs alone, while the second is usually combined with the first. The second part of the work deals with the pertinent experiments which have been performed and the interpretation of the results of these experiments. It is here that complete agreement among workers cannot be reached.

In the Conclusion, Chopard brings out into the open the main objections that have been raised against the whole theory of mimicry. The most important of these objections is based on the fact that resemblance lies in the eye and brain of the observer. We have no assurance that an insect appears the same to a bird as it does to us. Since man is not the natural enemy of the insects and birds are, this is important. We do know from experimentation that certain birds do not see dark red, blue, or violet. There may be other and more important differences between human and avian vision that we know nothing about. Some cases of "mimicry" are carried to the *n*th degree. For argument, let us admit that an insect is benefited by resembling a leaf, provided the insect sits on the right twig of the right plant. Can there be any added advantage in the insect's resembling a leaf partially eaten by a caterpillar and also attacked by fungus?

There are times when Nature seems to play practical jokes.

Edward A. Chapin

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A Concise Laboratory Manual and Atlas for Comparative Anatomy.

By W. H. Atwood. The C. V. Mosby Co., St. Louis. $2.75 (paper). 114 pp. + 39 plates; text ill. 1949.

This manual prescribes and directs the routine laboratory work of an undergraduate course in comparative anatomy. It covers 5 forms: amphioxus, shark, necturus, bullfrog, and cat. The text, in which structures to be studied are underlined, is preceded by both systematic and type study tables of contents. The 38 full-page plates in the back are perforated to permit removal. It is a planographed, sewed, paper-bound octavo, well constructed throughout. The general appearance, particularly in the design and drawing of the plates, should encourage the student to neat, careful work. It should be very useful in its field.

F. N. Low

◆

Practical Anatomy of the Dogfish, Necturus, and Cat.

By George C. Kent, Jr. Wm. C. Brown Co., Dubuque, Ia. $3.00 (paper). iii + 84 pp.; ill. 1948.

A careful series of directions for the study and dissection of the forms named in the title is given, along with a running commentary of relevant material. The 37 clear and fully labeled figures increase the value of the work.

John A. Cameron

◆

Laboratory Anatomy of the Cat. *Third Edition.*

By Ernest S. Booth; illustrated by Carl Petterson. Wm. C. Brown Co., Dubuque, Ia. $1.75 (paper). 57 pp.; ill. 1948.

This textbook of cat anatomy in special binding includes 61 excellent drawings all fully labeled and many full page charts, summarizing important information. The type is large and white space has been used effectively. The double-page folded diagram of the anterior spinal nerves is a notable feature.

John A. Cameron

◆

The Dissection of the Cat. *A Laboratory Manual.*

By Bruce M. Harrison. The C. V. Mosby Co., St Louis. $3.50. 109 pp.; ill. 1948.

This is an ambitious textbook and dissection guide with many fine illustrations on separate perforated pages. No labels are supplied, but label lines indicate the important loci to be considered and labeled by the student. There is a reference list of 55 titles and a 7-page section of Definitions of Terms.

John A. Cameron

◆

Atlas and Dissection Guide for the Study of the Anatomy of Domestic Animals. *Second Edition.*

By H. L. Foust and R. Getty. The Iowa State College Press, Ames. $2.50 (paper). 84 pp.; ill. 1947.

Beautiful plates of dissections of the horse, cow, pig, dog, chicken, and cat, with a key to each plate on the opposite page. Semi-schematic drawings of cross-sections at critical levels are included. Four chapters on the dissection of the dog follow the atlas, and each chapter has a useful list of references. The pages are not numbered, and there is neither index nor table of contents.

John A. Cameron

◆

Anatomy and Physiology for Students of Physiotherapy, Occupational Therapy and Gymnastics. *Second Edition.*

By C. F. V. Smout and R. J. S. McDowall. The Williams & Wilkins Co., Baltimore. $8.00. vii + 470 pp.; ill. 1948.

This textbook is designed for students of massage and medical gymnastics. It has been painstakingly prepared, and contains many original and excellent illustrations. It is well indexed, and contains the usual glossary. The chapters on Anatomy were prepared by the first author, who is Assistant Professor of Anatomy at the University of Birmingham, while McDowall of the Department of Physiology at the University of London prepared the part on Physiology. There are very few errors of fact of any consequence, and the method of presentation makes it highly suitable for those students for whom it was intended.

David B. Tyler

◆

Anatomy and Construction of the Human Figure.

By Charles Earl Bradbury. McGraw-Hill Book Co., New York, Toronto, and London. $7.50. x + 198 pp.; ill. 1949.

This is a guidebook for painters and sculptors of the human figure. It provides sound, selected information on the form and function of bones and muscles in so far as they affect the proportions and detailed appearance of the outer body of the adult man and woman. Having been written and illustrated by an accomplished portrait painter and experienced teacher of art, special emphasis is placed on the principles of reproducing the essential features as structural entities at rest or in action. The young art student is supplied with much good advice on minor technical matters, especially on how to proceed in drawing what he observes with anatomical understanding of underlying structures. Of greatest aid are the many pencil or charcoal drawings and beautifully plastic, colored illustrations which generously supplement the text. Secondary sex differences are fully dealt with, in so far as they concern the artist, though at times in a rather dogmatic manner. Age differences, however, are unfortunately hardly mentioned.

Among the many books on human anatomy for artists, at least in the English language, this is an outstandingly useful, authoritative, and beautiful one. Anatomical terminology has been held to an unavoidable minimum and defined in an adequate glossary. The book and its profuse illustrations are excellently printed, except that the color of muscles and tendons in some of the plates resembles more that of decomposing than that of fresh tissue.

A. H. Schultz

◆

Histopathology of the Teeth and their Surrounding Structures. *Third Edition.*

By Rudolf Kronfeld. Revised and edited by Paul E. Boyle. Lea and Febiger, Philadelphia. $8.00. 514 pp.; ill. 1949.

The format of this textbook by the late Dr. Kronfeld has undergone little change in the present edition. The number and order of the chapters remain the same. There are more illustrations, which now consist mostly of good quality photographs of both gross and histologic specimens. There are a few graphs, tables, and line drawings. A bibliography, emphasizing works in English but including some foreign language publications, closes each chapter.

Kronfeld's original purpose, "to illustrate by means of human specimens the actual tissue changes that correspond to certain well-defined clinical conditions," is accomplished well and still describes the book adequately. The normal histology and physiology of dental tissues are not included. Most of the book deals with topics of interest primarily to dental and oral pathologists. But there are some sections of more general appeal, notable among them the chapter on dental caries, rewritten by N. B. Williams. This disease progresses by decalcification of the teeth in localized areas which are exposed to acids formed by bacteria of the genus *Lactobacillus*. Numerous factors are now recognized to affect its incidence. Its absence among natives whose diet is uncivilized contrasts markedly with its frequency in groups subsisting on food prepared by modern methods. Among natives otherwise free of the disease its incidence is correlated with the accessibility of civilized food. The concentration of fluoride in drinking water is now understood to be a significant factor. In areas where the communal water supply contains more than 1.4 parts per million of fluoride the incidence of dental caries is only about one quarter as great as in areas with less than 0.5 p.p.m. Experimental studies involving the addition of fluoride to drinking water are still in progress. The structural quality of the teeth, malhygiene, and certain constitutional states are also correlated with its incidence. The picture is that of a disease which cannot be certainly prevented in individual cases but the incidence of which, because of complex etiological factors, can be reduced by proper measures applied to the population at large. The edition under consideration has been brought up to date and is written in clear, readable style. It should continue to enjoy popularity in its field.

F. N. Low

◆

Neurology. *Fourth Edition.*

By Roy R. Grinker and Paul C. Bucy. Charles C. Thomas, Springfield, Ill. $12.50. x + 1138 pp.; ill. 1949.

The fourth edition of Grinker's Neurology, with Paul Bucy as coauthor, and judging from the introductory note, as the active editor, is an excellent presentation of the field of neurology. Beginning with the technic of examinations, there is an excellent review of neuroanatomy and neuropathology, with every known syndrome or neurologic disease presented extensively and with quite adequate photographs or schematic drawings to illustrate the material. There is an extensive bibliography to complete the book. One finds little in the text concerning the psychosomatic and psychogenic aspects of some neurologic syndromes. This is all the more unusual considering Grinker's well-known interest in these facts. The book shows painstaking care in the presentation of the material and can be looked upon as one of the better textbooks and reference works on this subject.

Wendell Muncie

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Green's Manual of Pathology. *Seventeenth Edition.*

Revised by H. W. C. Vines. The Williams & Wilkins Co., Baltimore. $8.00. viii + 1200 pp. + 12 plates; text ill. 1949.

The reasons for the popularity abroad of the 17th edition of this British textbook of pathology are apparent. It is written with extraordinary clarity, both as to descriptions of lesions and discussions of pathogenesis, and it contains many well-chosen illustrations. The material is complete for virtually every phase of pathology; even subjects sometimes neglected by other pathologists, such as the teeth, malformations, and parasitology, are included. Furthermore, many clinical correlations are given, with excellent summaries of normal physiological findings. For instance, normal renal function and tests are adequately explained before the clinical and pathological findings in renal failure are described. In spite of its readability, the book possesses two serious faults which prevent its being an ideal textbook for American students. Discussions of pathological conditions are oversimplified by the frequent absence of conflicting opinions. Even such fundamental subjects as chronic passive congestion of the liver, jaundice, and infarction are handled in this dogmatic manner. This would be thwarting to students who wish to draw their own conclusions from all the data available. Furthermore, there is no bibliography. Not a single reference is listed to enable the student to consult the literature for material of historical importance, or to investigate controversial subjects. The approach is that used by the majority of textbooks of pathology today, i.e., a division into general pathological changes, followed by chapters on the specific diseases of each system. The terminology is British rather than American, but there are no more differences in classification than one finds between 2 American textbooks. In summary, although this is evidently a popular textbook in England, it can add but little to our already voluminous American collection of pathology textbooks.

Ella H. Oppenheimer

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ANIMAL PHYSIOLOGY

Laboratory Manual for Vertebrate Physiology.
By Donald M. Pace and Carl C. Riedesel. Drawings by Norma H. Pace. Burgess Publishing Co., Minneapolis. $3.25. viii + 227 pp. 1947.

This laboratory manual contains some 51 exercises in vertebrate physiology, including 15 nerve muscle experiments, 5 on the special senses, 17 on blood and circulation, 4 on respiration, 7 on nutrition, digestion, and absorption, and 1 on the endocrines (effect of insulin). Most of the experiments are designed for use of the frog or turtle, others for observations on man, and a few for the rabbit or dog.

David B. Tyler

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Some Aspects of Red Cell Production and Destruction. *Ann. N. Y. Acad. Sci., Vol. 48, Art. 7.*
By Eric Ponder, William B. Castle, Harry A. Charipper, William Dameshek, Albert S. Gordon, S. Granick, and F. S. Robscheit-Robbins. The New York Academy of Sciences, New York. $2.00 (paper). Pp. 577–704 + 3 plates; text ill. 1947.

This paper-bound pamplet contains a series of 6 papers resulting from a Conference on Red Cell Production and Destruction held by the Section of Biology of The New York Academy of Sciences on April 19 and 20, 1946. The articles cover the cytochemistry and architecture of the red cell (Ponder), the influence of the endocrine system on hemopoiesis (Gordon and Charipper), the effects of experimental hemorrhage on hemoglobin and red cell production (Robscheit-Robbins), the relationship of iron and porphyrin metabolism to erythrocytes (Granick), the etiology of macrocytic anemias (Castle), and hemolytic mechanisms (Dameshek). In keeping with the quality of the publications of the New York Academy of Sciences, this book is carefully printed and well assembled. Dealing as it does with the minutiae of one of the most exhaustively investigated cells of the animal body, it is suited primarily to the specialist's library. The papers are well written by competent authorities, but their scope is so restricted that their reading is bound to be uphill work for the general biologist.

F. N. Low

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The Renal Origin of Hypertension. *A Monograph in American Lectures in Pathology. American Lecture Series, Publication Number 14.*
By Harry Goldblatt. Charles C. Thomas, Springfield, Ill. $2.75. viii + 126 pp.; ill. 1948.

Goldblatt, one of the better known students of this subject, has prepared an excellent little monograph in which 20 years of experimentation are summarized and discussed. The book is essentially designed for those whose interest is not sufficiently specialized or who do not have enough time to search out and read the original articles in this field. The monograph is readable and should prove of value to teachers of physiology in preparing lectures on a subject in which they may have little or no personal experience.

The following topics are included: methods of producing experimental renal hypertension; the effects of various experimental procedures, such as moderate and great constriction of one or both main arteries of the kidneys; the pathological changes that occur in various organs of animals showing persistent hypertension; the various mechanisms in the development of experimental renal hypertension; renin, hypertensinogen, hypertensin, and hypertensinase; the mechanism and site of formation and release of renin; the juxtaglomerular apparatus; the treatment of hypertension and a discussion of the similarities and differences between human, essential, and experimental renal hypertension. This is a short but excellent monograph that can be read easily in an evening by students of medicine.

David B. Tyler

* * *

The Physiology of the Eye.
By Hugh Davson, with a foreword by Sir Stewart

Duke-Elder. The Blakiston Co., Philadelphia. $7.50. xii + 451 pp.; ill. 1949.

There are in the field of vision excellent comprehensive handbooks by Duke-Elder and Helmholtz and many highly specialized monographs by Bartley, Granit, Polyak, Willmer, and others. It is difficult, however, to find well-balanced texts at an intermediate level. Davson's book is a welcome addition to the literature, since it is specifically designed as a general textbook for medical students, opticians, and physiologists. The contents of this volume are divided into 5 sections dealing respectively with intraocular dynamics and the transparent tissues (61 pp.); the mechanism of vision—photochemistry, flicker, acuity, adaptation, and the like (115 pp.); muscular mechanisms (75 pp.); visual perception—depth perception, dominance, rivalry, central pathways of the visual system (68 pp.); and optics (116 pp.). The weakest section seems to be the one which deals with visual perception.

Visual scientists will find much to complain about in this book because it is possible to compress the enormous literature on vision into a small text only by eliminating much interesting material and greatly condensing the rest. Considering the difficulty of writing a small book in this field, this is well done. It discusses a large number of topics in a competent way, and it should provide the student with a reasonably thorough and well-rounded introduction to the field.

A. Chapanis

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Biological Actions of Sex Hormones. *Second Edition. Entirely revised and reset.*

By Harold Burrows. Cambridge University Press, London and New York. $8.50. xiii + 615 pp. 1949.

This book is a new edition of a work originally published in 1945 (cf. *Q.R.B.*, 21: 299), which has since been widely known and used by students and workers in the field as a source book and general reference. The present edition follows closely the form of the original, although now greatly enlarged to cope with an enormous increase in the literature. The book is compactly organized into 6 major sections, as follows: the gonadotrophins; the gonad hormones—general aspects and relations; the androgens; the estrogens; the progestins; and the sex hormones of the adrenal cortex. The treatment of this immense area comprises not only the activities of the multiplicity of "sex hormones" in the physiology of the adult organism and in the development of the reproductive organs and functions; it deals also to a considerable extent with their complex interrelations with other endocrine glands and functions, in particular the pituitary and the adrenal. Each main section is further classified around numerous topics and subtopics. This breakdown has been carried out in considerable detail and contributes greatly to the usefulness of the book for general reference. The point of view throughout, however, is essentially that of the physiologist; the already very large literature on the experimental analysis of sex differentiation in all its various aspects is widely scattered among many sections and nowhere receives unity of treatment. As in in the first edition, considerable attention is given to the field of cancer research where hormones are involved.

In execution this plan has produced a well classified compendium of information. The principal data are assembled and set down concisely, and on the whole clearly, at least within limits imposed by the extreme brevity of treatment. There is welcome assistance to the reader in the form of numerous charts and tabulations. But there is too little attempt at evaluation of methods or data, and conclusions are reported for the most part in the form in which they are set forth in the original sources. In so comprehensive a field, it is of course impossible to report everything—some selection there must be; but there is sometimes room to question how much of what appears is attributable to selection and how much to the limits of one man's reading capacity.

This observation leads directly to the chief criticism which must be made. It is disappointing to find that the outstanding fault of the first edition—serious gaps in coverage—appears again in the present volume. Various important topics, the earlier history of which is developed, seem to have been passed over almost entirely so far as the literature since 1940 is concerned. Cases in point are the role of hormones in the control of sex differentiation, especially in mammalian embryos, and the very important effects of castration, both in the prenatal and postnatal periods of development. Again, in the section on the adrenal cortex the usual emphasis is placed on sex dimorphisms, in particular the sexual significance of the x-zone of the mouse's adrenal. The author, however, seems unaware of much recent work which has failed to produce any evidence of androgenic activity in this tissue. Publication at the very end of the war obviously accounted for many such omissions in the first edition, because of difficulties of access and communication, but these deficiencies should by now have been largely removed.

The new volume is durably and attractively bound and printed on a superior quality of paper. It has a well classified topical index and an enormous bibliography running to 35 closely printed pages. These features, together with the synoptic plan of organization, make the work convenient to use and extremely valuable as an introduction into a complicated field of investigation.

Robert K. Burns

ESSENTIALS OF GYNECOLOGIC ENDOCRINOLOGY *With Sections on the Male.*

By Gardner M. Riley. Caduceus Press, Ann Arbor. $3.00 (paper). x + 205 pp. + 1 plate; text ill. 1948.

This book offers an excellent synopsis of the basic facts of endocrinology, applied to the diagnosis and treatment of diseases of the female sex organs. In selecting these basic facts the author has drawn mostly on well-documented clinical material. He seeks to give a picture of human endocrinology rather than to describe the findings made on laboratory animals. It is a book for the physician rather than the biologist. One minor flaw in this excellent piece of work is the insufficient discussion of terminology in the chapter on the chemistry of the sex hormones. Alpha and beta structural configurations of the steroids are mentioned, but without further explanation these terms mean little if anything to the average medical reader. The illustrations are well chosen, and in spite of their excellent reproduction the price of the book is very reasonable. The book is recommended highly to students and practitioners of medicine. It should be on the shelf of every practicing gynecologist.

W. FLEISCHMANN

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CONTRIBUCIÓN DEL COEFICIENTE CITOLÓGICO *a la Fisiología y Patología de la Correlación Hipofisotiroidea.*

By Estanislao Del Conte. Librería y Editorial el Ateneo, Buenos Aires. $(Arg.)22.00. 87 pp. + 16 plates; text ill. 1949.

This is a very good monograph on the bioassay of the pituitary thyrotrophic hormone in the blood. The test object is the epithelium of the thyroid gland of the guinea pig. The test is very sensitive. The excess of thyrotrophic hormone in the blood of patients suffering from some forms of toxic goiter could be clearly demonstrated by this method. The histological technique is discussed in detail, with good illustrations. An excellent bibliography is included in this book, which can be recommended to specialists in the biological assay of hormones.

W. FLEISCHMANN

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ELEMENTARY ANESTHESIA.

By W. N. Kemp. The Williams & Wilkins Co., Baltimore. $5.00. xii + 289 pp.; ill. 1948.

The author introduces the subject of elementary anesthesia with an excellent historical resumé. In the following chapters the pharmacodynamic and physiological considerations are discussed in a limited manner. The barbiturates, analeptic drugs, and curare are treated in so far as their place in anesthesia is concerned. The main portion of the text treats in a general manner the techniques of anesthesiology. Among these are included endotracheal anesthesia, anesthesia adapted to the patient's handicaps, anesthesia for thoracic surgery, and spinal anesthesia. Of special interest is the chapter on anesthesia for non-surgical conditions, which include such cases as acute barbiturate poisoning, sprained ankle, painful shoulder, and others.

The author has attempted to include in a comparatively small volume the entire field of practical anesthesiology. Of necessity it has been covered in a superficial manner. The diagrams and illustrations in the book are of special help in explaining the text. The style of the author is clear and concise, and this book should be very helpful to those who wish to review rapidly the field of general anesthesia.

JOHN C. KRANTZ, JR.

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TEXTBOOK OF ANESTHETICS. *Seventh Edition.*

By R. J. Minnitt and John Gillies. The Williams & Wilkins Co., Baltimore. $8.00. viii + 568 pp.; ill. 1948.

The textbook of Minnitt and Gillies has now passed through 7 editions. This bespeaks the value of this compendium on anesthesia to the practicing anesthesiologist. In the seventh edition the general arrangement of the subject matter which appeared in the previous editions has been maintained. Newer subjects which have made their advent in the field of anesthesia, such as curare, and the new techniques in the administration of spinal anesthesia have been included. The authors have included a large number of cuts depicting new devices which have been developed for the anesthesiologist. The newer types of gas bags and anesthetic machines are shown. Of special interest is the chapter on the choice of an anesthetic. In this the authors consider patients with various diseases and suggest the best choice of an anesthetic under the particular conditions. On the whole, the book is well written and is recommended as a general and rather comprehensive treatise on the practical aspects of anesthesiology, containing sufficient pharmacologic background to warrant the consideration of the modern anesthesiologist.

JOHN C. KRANTZ, JR.

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INDUSTRIAL TOXICOLOGY. *Second Edition Revised and Enlarged.*

By Alice Hamilton and Harriet L. Hardy. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York. $7.50. x + 574 pp. 1949.

Mention is made in the preface of this second edition of the enormous expansion in the number of solvents, metals, and radio-active substances encountered in industry since the first edition appeared in 1934. For example, an entire chapter in the present volume is devoted to beryllium poisoning. Rapid developments in synthetic organic chemistry are constantly modifying industrial processes and consequently changing the toxicology picture.

There are 28 chapters in the book. Most of the common industrial metals are considered from the toxicological standpoint. One chapter is devoted to the asphyxiants, carbon monoxide, carbon dioxide, the cyanides, and hydrogen sulfide. The aromatic organic chemicals, including the volatile solvents, are discussed in 4 chapters. The remaining 10 chapters deal with the aliphatic series; chlorinated and brominated hydrocarbons; carbon disulfide; turpentine and tobacco; synthetic rubber; oil folliculitis; occupational cancer of the skin, lung, and bladder (3 chapters); radiant energy and stilbestrol. The material in each chapter could be made more useful to the reader by arranging the data under headings or captions, e.g., local effects, effects on the central nervous system, effects on liver and kidney, etc. Following such a schema the information would be more quickly available and more easily correlated. In addition, the authors might have evaluated the data from the literature more completely and have expressed opinions.

Only a page and a half are devoted to the rather important toxic insecticide, DDT, and the index reference to it is incorrect. The bibliography contains 1300 references. The volume appears adequate and will probably be useful to industrial hygienists, toxicologists, and those concerned with health hazards in industry.

C. Jelleff Carr

Industrial Toxicology.

By Lawrence T. Fairhall. The Williams & Wilkins Co., Baltimore. $6.00. xii + 483 pp. 1949.

The author is Scientist Director of the Chief of the Industrial Hygiene Laboratory, U. S. Public Health Service. Rather than present the toxic effects of a substance as a series of case reports, he has attempted an appraisal and interpretation of the literature on each compound. As suggested in the Preface, this approach serves to give the industrial hygienist an evaluation of toxicity without having to digest a great volume of literature or to seek out many obscure publications. A short list of recent and more pertinent subject references is given at the end of each discussion.

As the physiologic response to a compound depends in large measure upon its physical and chemical characteristics, such as volatility, solubility, etc., these data have been included for each substance. Thus the occupational hazard may be more effectively evaluated by the reader. A novel feature of the text is the attempt to gather from governmental and other sources the extent of the production and use of a given material. The substances are arranged alphabetically in each part. Part I includes 71 inorganic substances. Part II includes 134 organic compounds. The introduction includes a brief yet comprehensive discussion of the relationship between chemical constitution and physiologic response and experimental toxicology.

The volume is well printed, attractively bound, and appears to be relatively free from typographical errors. The index is very complete. This is an excellent reference work, and the reviewer recommends the volume to toxicologists, pharmacologists, and those charged with the responsibility of worker protection in industry. The very complete coverage, with references, of analytical methods for each substance will appeal to laboratory workers especially.

C. Jelleff Carr

BIOPHYSICS

Neutron Effects on Animals.

By the Staff of the Biochemical Research Foundation, Dr. Ellice McDonald, Director. The Williams & Wilkins Co., Baltimore. $3.00. viii + 198 pp.; ill. 1947.

This is a report of the various studies made by members of the Biochemical Research Foundation on the effects of fast neutrons produced by a cyclotron. The median lethal dose for rats was found to be between 60 n and 120 n in single exposures. Male rats exposed to 10 n per day for a total of 120 n all died within 60 days, whereas females survived in a few instances. Repeated doses of 1.8 n (6 times per week) reduced the rate of growth and increased the incidence of tumors, but 3 doses per week had no marked changes in the blood up to 9 months. In the more acute experiments, a lowering of the leukocyte and erythrocyte count was generally found with exposures above 17 n. Other studies involved physiological, chemical, and histological changes in the tissues of rats following neutron exposures. The changes noted were qualitatively similar to those of roentgen irradiation. Certain effects of neutrons on dogs, rabbits, and other organisms have also been reported in this book.

Titus C. Evans

Trilinear Chart of Nuclear Species.

By William H. Sullivan; art work by Kay Benscoter. John Wiley & Sons, New York; Chapman & Hall, London. $2.50 (paper). Continuous 10½-inch-high strip. 1949.

This is a useful chart of some of the newer physical constants for nuclei; indeed, it has compressed into it an amazing amount of detail about recent values of various natural and artificially produced elements. It is unfortunate to note that many of the values for the half-lives of radioactive isotopes are not printed legibly.

Aside from this, the chart will undoubtedly have considerable appeal for workers in radioactive isotope chemistry.

L. J. Mullins

BIOCHEMISTRY

Chemistry and Uses of Insecticides.
By E. R. de Ong. Reinhold Publishing Corp., New York. $6.00. viii + 345 pp.; ill. 1948.

Technical books mirror the interests of the author or they would seldom be written. De Ong is a consulting entomologist. He has, therefore, prepared a compilation of very useful and practical facts for practicing entomologists. One of the reviewer's functions is to learn whether the contents of a book agree with the title. The word "insecticide" means to De Ong a chemical to control pests of plants, animals, or man—weed killer, bactericide, fungicide, rodenticide, or insecticide. The new word "pesticide" is a better term for so inclusive a meaning. The organization of the book revolves primarily around specific compounds, which are each described in terms of tonnage, manufacture, shipping, uses, and compatibility. Few structural formulae are given. De Ong's book may be recommended to the practical trade. It is less useful to the farmer than Stapley's book (reviewed on p. 339), more useful to those who advise farmers.

James G. Horsfall

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Chemistry of Insecticides, Fungicides and Herbicides. *Second Edition.*
By Donald E. H. Frear. D. Van Nostrand Co., Toronto, New York, and London. $6.00. x + 417 pp.; ill. 1948.

During the six years which elapsed between the first and second editions of Frear's useful book, new pesticides appeared with remarkable frequency. DDT and other chlorinated hydrocarbons revolutionized insecticides, and the hormone weed killers opened a wholly new field. Dithiocarbamates and glyoxalidines appeared as practical new fungicides. This is an excellent source book for chemical data on pesticides and the reactions involved in their manufacture. It is not a set of instructions for use nor does it contain very many biological data, although the book does indicate some reactions that may be involved in pesticidal action. It would be of no interest to farmers, of little interest to advisors of farmers, but of considerable interest to a host of biologists and chemists.

James G. Horsfall

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The Mode of Action of Organic Insecticides. *Chemical-Biological Coordination Center, Review Number 1.*
By Robert L. Metcalf. National Research Council, Washington, D. C. $1.00 (paper). 84 pp. 1948.

The biologist, like the chemist, employs reagents to study reactions. The chemist uses acids and bases, oxidizers and reducers. The biologist uses foods and poisons. He accelerates his organism on the one hand, discourages it on the other.

The National Research Council through its Chemical-Biological Coordination Center is doing yeoman service for biologists in assembling the data on the relation of organic substances to biological action. As one of its activities, it is to publish reviews, Metcalf's being the first. We hope that successors will live up to the quality of the first.

Metcalf has not been content merely to describe the activity of insecticides. He has tried, meager as the data sometimes are, to discuss the dynamics of the process. He ably discusses the problems of the permeation of toxicants into insects. The reaction flasks of biologists are such organisms as cockroaches and Japanese beetles. Beyond that any similarity to chemists' problems is purely coincidental. The chemist pours his reactants together in a beaker or flask and stirs them vigorously. The entomologist must put his reagent outside the Japanese beetle and hope for penetration. Moreover, he cannot stir the reactants together. If he stirs up the innards of a beetle, he has a beetle no longer. In short, a discussion of reagents in biology must involve problems of penetration into and permeation through the body of an organism. Metcalf does this. He discusses the molecular structure of organic insecticides in terms of "toxophores" and "conductophores," in terms of the classical Overton-Meyer theory. For example, the bis (parachlorophenyl methane) moiety of DDT is apparently the toxophore and the trichloromethane moiety the conductophore. The latter assures penetration through the lipoid cuticle; the former assures death of the bug.

Metcalf's memoir is of interest almost exclusively to the frontier biologist. Those interested in biological systems and reagents for them must not miss this volume.

James G. Horsfall

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Cation Exchange in Soils. *A. C. S. Monograph Number 109.*
By Walter P. Kelley. Reinhold Publishing Corp., New York. $4.50. xvi + 144 pp.; ill. 1948.

This work represents Kelley's considered viewpoint on cation exchange in soils following many years of fruitful research. It therefore bears a strong stamp of his personality. It is, however, much better balanced than any compilation of a single individual's researches could possibly be, although it does not quite attain the coverage implied by the title. The chief defect is the very scanty treatment accorded to soil organic matter.

The first chapter deals with the history of cation exchange. It is extremely well written, and the author has been at great pains to achieve a connected narrative, not merely a series of abstracts. In Chapter 2, modern views on the nature of the materials involved in cation exchange in soils are developed, the organic matter, as noted above, being very briefly dismissed. The third chapter is devoted to cation exchange equations, and the fourth to principles of cation exchange. Many readers may prefer to take these in reverse order, since Chapter 4 contains much of the factual basis for the assumptions used in deriving the equations. The next chapters, on Exchange Capacity and Kind of Exchangeable Cation in Various Soil Types and The Determination of Exchangeable Cations, are of especial value, since much of Kelley's research has been devoted to these topics. The chapter on Cation Exchange in Relation to Soil Properties is an outline rather than an extended treatment. The last chapter deals with the identification and estimation of the clay minerals, again in outline rather than in minute detail. X-ray and thermal methods are adequately discussed, but optical methods fare somewhat badly. In general, this work can be confidently recommended to all who seek to know more of the intricacies of cation exchange and related matters as they affect soils and the crops which grow upon them.

C. Edmund Marshall

MICROBIOLOGY

Mikrobielle Symbiosen in Pflanzen- und Tierreich. *Die Wissenschaft, Band 94.*

By Traugott Baumgärtel. [Friedr. Vieweg & Sohn, Braunschweig]; J. W. Edwards, Ann Arbor. $3.75. vi + 132 pp.; ill. [1940] 1946.

The German original of this book, lithoprinted by authority of the Alien Property Custodian, was published in 1940. As the author is a bacteriologist, bacterial symbioses dominate (57 pp.), and fungus symbioses come next (30 pp.), but the book begins by considering the oldest known symbioses, those of the algae.

The term symbiosis is used in the broadest sense of the word. The author includes even sequences where one species profits from the products of the preceding flora or fauna. He also discusses true symbiosis where both forms profit, as well as the "master-servant type," and perfectly equalized cases as well as unequalized cases bordering on parasitism. A distinction is made between endosymbiosis and exosymbiosis.

After a brief discussion of the lichens, the well-known symbiosis of algae and fungi, there follows a consideration of the symbiosis of protozoa with green algae, the Zoochlorellas, or with yellow or brown algae, the Zooxanthellas. Even echinoderms and mollusks can join in such a symbiosis with algae. The resynthesis of symbiosis from the separately cultivated symbionts is discussed in some detail.

A chapter on fungus symbioses begins with a description of the two different types of mycorrhiza. These descriptions are so condensed that the uninitiated cannot follow. The account of fungus symbioses with animals begins with a description of fungus-cultivating insects, such as ants. (This extends the definition of symbiosis to a point where we can also speak of a symbiosis between man and wheat.) Quite different are the wood-boring beetles whose larvae have an abnormal development of certain parts of their intestines with these abnormal cells containing the symbiotic organisms.

The best-known example of bacterial symbiosis with plants is that of the nodule bacteria of the legumes. The attempt to explain nitrogen fixation within the nodule does not include the latest American research. Bacterial symbiosis with plant-eating beetles is described in some detail in so far as the morphology of the beetles is concerned, but the role of the bacteria is not mentioned, though in some cases these bacteria can be obtained in pure culture. The same criticism applies to the descriptions of the bacterial symbioses with bugs, scales, aphids, and ants. The book gives details of the mode of transmission, but does not mention the role of the bacteria and their usefulness to the insects. Examples are given of luminescent bacteria causing luminescence of various marine animals.

The symbiosis of bacteria with mammals is exemplified by a description of the bacteria of the intestine of the horse. Our latest knowledge of the ruminant flora obtained by cutting a "window" into the ruminant has been acquired since this book was published. The extensive chapter on the symbiosis of bacteria with man stresses rather one-sidedly the *Lactobacillus bifidus*, but fails to mention the formation of vitamins by the intestinal flora proved by the application of certain sulfa drugs that kill the intestinal bacteria.

The book is written interestingly in a semipopular vein. Because it was written 10 years ago, it lacks the latest developments in this science. Nevertheless, it is stimulating for the reader who works in this borderline field.

Otto Rahn

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Germ-Free Life Studies. *Lobund Reports, Number 2, February 1949.*

Edited by James A. Reyniers. The University of Notre Dame, Notre Dame, Indiana. $2.50 (clothbound); $1.75 (paperbound). viii + 162 pp.; ill. 1949.

No. 1 of the Lobund Reports was reviewed in Q.R.B. 23:75. The present number contains 3 papers: Rearing Germ-Free Chickens; Some Observations on Germ-Free Bantam Chickens; and The Need for a Unified Terminology in Germ-Free Life Studies; all of them by J. A. Reyniers, P. C. Trexler, R. F. Ervin, M. Wagner, T. D. Luckey, and H. A. Gordon.

The first paper reviews previous attempts to rear germ-free chickens, and also gives a great deal of detail on the specialized equipment and methods used by the present authors, involving the sterilization of fertile eggs and the use of a sterile diet for the chicks. The second paper deals with the results of the germ-free growth of poultry. The Rose Comb White Wyandotte Bantam chicken is preferred because of its small size. This variety was reared through its entire life cycle and into a second generaton under aseptic conditions on an autoclaved diet. Growth was reasonably good, but egg production was sporadic and hatchability was poor. Compared to normal controls, there were differences in the development of the lymphoid system and intestines. The fat, ash, vitamin content, and moisture of the liver were essentially normal. The brain showed a higher potassium content. The vitamin content of the ceca was high, despite the absence of an intestinal flora. Antibodies against certain bacterial antigens could be demonstrated in low titer, probably owing to dead bacteria in the food. The third paper discusses the desirability of having a uniform terminology in this experimental field. No very definite recommendations are made, although the authors seem to incline toward the use of the general term *gnotobiotics* (Greek, γνωτός-known, βίος-life), which leads to such derivative terms as *gnotobiote* for an animal free of contamination (or associated only with known microorganisms).

Like the previous number, the publication will be indispensable to those working in the same field and of great collateral interest to workers in animal nutrition in general. The editors hope that eventually persons in other institutions may submit contributions. In view of the highly specialized methods and equipment required, it may be doubted whether the field will ever become a highly active one.

WALTER C. TOBIE

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THE NATURE OF THE BACTERIAL SURFACE. *A Symposium of The Society for General Microbiology, April, 1949.*

Edited by A. A. Miles and N. W. Pirie. Charles C. Thomas, Springfield, Ill. (printed in Great Britain). $3.00. viii + 179 pp. + 12 plates. 1949.

The depiction of the bacterial cell as a bag of enzymes has been criticized repeatedly for ignoring other contents of the cell and their functional integration. Most discussions of biological surfaces have, however, degenerated into uninformed speculation on topics like specific permeability as a metabolic regulation, concerning which we have practically no concrete experimental data. This symposium has steered clear of such speculations, for the most part, and is concerned primarily with the discussion of factual information on the composition, structure, and function of bacterial surfaces. Despite a prefatory apology by N. W. Pirie for the omission of certain aspects of bacterial surfaces, the contributors represent a wide variety of viewpoints: chemistry, immunochemistry, morphology, bacterial virology, biophysics, and genetics.

Immunochemical studies bearing on bacterial surfaces are reviewed by W. T. J. Morgan, A. A. Miles, and E. T. C. Spooner. The methodology of this approach is carefully studied by these authors, and their conclusions concerning the inadequacy of various isolated criteria for the surface role of immunochemically identified components are well taken. These authors have also contributed a useful discussion of the difficulties of defining the boundary between the cell proper and its environment, part of which—e.g., capsular secretions—may be produced by the cell. A related tack is amplified by Harriett E. Taylor in a review of recent work on the pneumococcus transformations. M. Stacey's interpretation of the transformation as a "starter" effect of the capsular polysaccharide during its enzymatic synthesis is discussed in critical detail.

The osmotic functions of the bacterial surface are taken up by P. Mitchell. A model hypothesis for the accumulation of amino acids is developed for glutamic acid on the basis of a surface envelope consisting of a lipid layer 50 Å thick. The amino acid is converted into lipid-soluble glutamine at the outer surface, and is hydrolyzed to glutamic acid again at the inner interface. Many workers have postulated such biochemical cycles as accumulation mechanisms. However, this hypothesis is clearly inapplicable to those streptococci which require glutamine as a growth factor.

M. Stacey reported the studies by his colleagues and himself on the nature of the Gram-staining complex of Gram-positive bacteria. T. F. Anderson gave a detailed account of the factors involved in adsorption of bacteriophage to the bacterial surface, with new data on the kinetics of activation of certain phages by adsorption cofactors (tryptophane). As commented by A. Felix, the simplified picture of adsorption as a "simple steric fitting of complementary rigid surface structures" is replaced by "dynamic processes involving enzymic steps of degradation and synthesis." But to infer that phages are "indigenous products of the bacterial cell and not separate viruses" is to ignore a large body of evidence for their exogenous origin, some of which is cited by Anderson. The volume closes with an account by A. Pijper of his sunlight-darkfield observations on the functions of bacterial flagella. His heterodox views have excited considerable discussion in this volume, and elsewhere.

Each paper is accompanied by a paraphrase of the discussions, which are very lively and true-to-life. The discussions and the photographic illustrations are a very valuable part of the book. The volume is well made up, and essentially free from typographical errors (except precipitin for precipitinogen, p. 130). The book should be read by every serious student of bacteriology and cell physiology, and it may be hoped that this timely discussion will help to focus more intensive examination on a group of problems which has suffered, in the past, from too high a proportion of speculation to experiment.

J. Lederberg

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Plant Viruses. *Second Edition. Methuen's Monographs on Biological Subjects.*

By Kenneth M. Smith. Methuen & Co., London. 6s. x + 78 pp. + 8 plates; text ill. 1948.

The author of this pocket-sized treatise is one of the world's best qualified persons to perform the difficult task of summarizing modern knowledge about plant viruses. In a field where the application of technics of protein chemistry and physics has brought spectacular advances in our knowledge of the physical nature of viruses, there is great need for the maintenance of a broad and integrated biological viewpoint. Smith has done this, giving due attention to the pathological physiology of the virus-infected plant, in addition to presenting a concise summary of the modes of transmission of plant viruses. The chapter on viruses in relation to their insect vectors reflects the extensive knowledge and experience of the author in that particular area. The control, serology and classification of plant viruses are covered briefly but well. The pioneer work of Vinson from 1929 to 1933 on the chemical isolation and purification of tobacco mosaic virus was followed by the isolation of the same virus in paracrystalline form by Stanley and the determination of its macromolecular nature. The discovery of the nucleoprotein structure of plant viruses by Bawden and Pirie was a great step forward. A tremendous surge of activity followed in both the animal and plant virus fields. This second edition (1st ed., *Q.R.B.*, 11:106) of *Plant Viruses* has been entirely rewritten to include many of these important developments. The final chapter presents some of the theories concerning the origin of viruses. Such an abbreviated account of the plant virus field must of necessity omit much of importance. Nevertheless, I was impressed by the amount of material included in so few pages and the balanced scientific manner of its presentation. This little book presents in an interesting way the broad outlines of the plant virus field.

M. W. Woods

HEALTH AND DISEASE

Revista da Associação Médica de Minas Gerais. *Vol. 1, No. 1, August 1949; No. 2, December 1949.* Pp. 1–229.

Edited by Aulo Pinto Viegas, Hilton Rocha, Lucas M. Machado, E. Livio Renault. Associação Médica de Minas Gerais, Belo Horizonte. Annual subscription, Cr$ 60.00 or U. S. $5.00; single numbers, Cr$ 20.00. Published four times a year.

Although it is primarily a medical journal for original papers in the Portuguese language, this new journal carries some papers in English, e.g., in No. 2: BCG Vaccination in Rio de Janeiro (J. Feldman); Hemosedimentation Test in Obesity (A. P. Viegas). There is a section in each issue of a more general sort, and headed "De Rebus Pluribus."

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Medical Disorders of the Locomotor System Including the Rheumatic Diseases.

By Ernest Fletcher. The Williams & Wilkins Co., Baltimore. $11.00. xii + 625 pp. + 1 chart; text ill. 1947.

The author of this book is a British physician who presents a major interest in the art of medicine as applied to arthritis. He has extended his considerable personal abilities by calling upon 9 contributors in special subjects. The scope of the text has thus been extended to the medical aspects of the locomotor system.

The contents may be very approximately divided as follows. The first 100 pages consist of introductory subjects, which include a classification of rheumatic conditions, examination of the patient, physiology, and anatomy. The next 340 pages contain a discussion of arthritic conditions. This is followed by about 150 pages devoted in the main to allied locomotor conditions. The remaining pages contain a chapter on physical therapy, and an appendix containing empirical aids to diagnosis and treatment of the several diseases. Each of the 35 chapters is followed by a bibliography which draws extensively from American as well as British sources.

A biologist will observe that this book is not directed toward his ordinary interests, but rather that it stresses the empirical and clinical aspects of musculo-skeletal diseases. Pure science is significantly minimized in favor of clinical and practical discussions. Yet a biologist who is interested in arthritis can glean historical and research references from the bibliographies, while having his clinical understanding of the several rheumatic diseases extended through relatively pleasant reading. The text gives no information on the recent trend toward hormone research and therapy as applied to arthritis. In short, a biologist with clinical leanings will find this book of interest; others will benefit only slightly from its message.

Nephi K. Kezerian

CARDIAC CATHETERIZATION IN CONGENITAL HEART DISEASE: *A Clinical and Physiological Study in Infants and Children.*

By André Cournand, Janet S. Baldwin, and Aaron Himmelstein. The Commonwealth Fund, New York; Geoffrey Cumberlege, Oxford University Press, London. $4.00. viii + 108 pp.; ill. 1949.

Cardiac catheterization has only recently become an accepted procedure in the diagnosis of congenital heart disease. Progress has been rapid since the use of this technique in the study of auricular septal defects was introduced 5 years ago. The groups working respectively under Cournand, Bing, and Dexter have been outstanding contributors to the field, and the material in this short monograph from Cournand's group is to be considered authoritative. Although the method of study may come to have wider application in normal cardiac and pulmonary dynamics, in pharmacology, and in acquired heart disease, its value in the study of congenital cardiac anomalies is already firmly established.

In brief, cardiac catheterization consists of passing a flexible venous catheter (under electrocardiographic and roentgenologic control) into the right heart chambers and pulmonary artery for the purpose of sampling blood and obtaining blood pressures. In patients with septal defects, the left heart also may be available for study. When simultaneous expiratory gas samples, right heart blood (mixed venous blood), and arterial blood samples are obtained, it is possible to calculate the cardiac output by means of the Fick principle: oxygen consumption divided by arteriovenous oxygen difference equals cardiac output. Variations of the Fick formula make it possible to estimate the magnitude of cardiac shunts, and of pulmonary flow when this differs from systemic flow.

The opening section of the book is a concise outline of the physiological methods, techniques, and equipment used in cardiac catheterization. The roentgenographic appearance of the catheter in the heart and the characteristic blood pressure curves are well illustrated; necessary calculations are described; and the importance of the electrocardiograph in avoiding dangerous arrhythmias is stressed. Physiologists will perhaps be disappointed by the pressure curve artifacts that may be introduced by the use of a long catheter, but the basic significance of the records cannot be denied. The second portion of the book comprises 17 case presentations encompassing a wide variety of single and multiple cardiac defects. The lack of supporting autopsy material is unavoidable and not of a serious nature. The authors are to be congratulated on the diagrammatic clarity and completeness of their clinical studies and on their thoughtful analysis of the data.

E. CONVERSE PEIRCE, 2ND

EPILEPSY. *Psychiatric Aspects of Convulsive Disorders. Proc. 36th Annual Meeting, Amer. Psychopathol. Ass., Held in New York City, May 1946.*

Edited by Paul H. Hoch and Robert P. Knight. Grune & Stratton, New York. $4.00. viii + 214 pp.; ill. 1947.

These 15 papers cover a wide variety of material, ranging over the historical, social diagnostic, clinical, and medical aspects of epilepsy. The subject matter includes the genetics of epilepsy (Kallman and Sander), the prevalence of epilepsy (Malzberg), its social implications and management (Collier), antisocial aspects of epilepsy (Foxe), personality of the epileptic (Piotrowski), differential diagnosis of epilepsy (Diethelm), diagnostic testing in convulsive disorders (Mayman and Rapaport), the psychopathology of epilepsy (Mittelman), some psychopathological aspects of organic brain damage (Hock), experimental production of epilepsy in animals (Kopeloff and others), electroencephalography in epilepsy (Jasper), and maternal nutritional deficiency and the incidence of sound-induced convulsions in young albino rats (Patton). The volume stresses the psychiatric aspects of epilepsy, dealing not only with the disease process but also with the general well-being of the epileptic patient. Emphasis is placed on the psychiatric help and counsel which an epileptic patient needs besides the medical treatment. The general clinical approach, rather than research, is stressed.

SAMUEL LIVINGSTON

EPILEPSY AND CONVULSIVE DISORDERS IN CHILDREN. *McGraw-Hill Series in Health Science.*

By Edward M. Bridge. McGraw-Hill Book Co., New York, Toronto, and London. $8.50. xiv + 670 pp. + 12 plates; text ill. 1949.

Bridge's work on epilepsy and convulsive disorders in children represents a milestone in medical literature. The presentation of the subject is such that it is an invaluable and indispensable reference for the physician, student, nurse, social worker, or layman who seeks knowledge and orientation about convulsive disorders in children. The treatment of the subject is unique in many respects. Emphasis has been placed first on the underlying forces that give rise to the symptoms. The various manifestations of epilepsy are treated from a broader viewpoint than description alone. Treatment is scattered throughout the presentation; in particular, as part of the discussion of the various manifestations: major convulsions, minor seizures, etc. The importance of psychosomatics as a basic concept in the treatment of convulsive disorders is stressed.

The wealth of material in this book is the result of careful and numerous scientific studies and analyses carried out over a period of years by the author and his associates on 742 children treated at the Johns Hopkins Hospital Epilepsy Clinic, integrated with the pertinent literature and medical research on epilepsy. Bridge probes the problem of convulsive disorders in children not by searching for a single cause but by evaluating the relative importance of (a) heredity, (b) structural defects in the brain, (c) physiological disturbances, (d) personality maladjustment, and (e) environmental strains in producing the symptoms of recurrent seizures. I strongly recommend that this book be read by all who are concerned either socially or medically with the problems of convulsive disorders in children. It fills a gap which has existed for many years.

SAMUEL LIVINGSTON

* * *

L'ALLERGIE TUBERCULEUSE CHEZ L'HOMME. *Étude de l'Allergie au Cours des Principales Localisations de la Tuberculose de l'Homme, ainsi qu'au Cours de l'Infection Tuberculeuse Latente. Le Mecanisme de l'Allergie Tuberculeuse. Le Retentissement de l'Allergie sur l'Évolution des Lésions Tuberculeuses. Allergie et Immunité Antituberculeuse. Collection de l'Institut Pasteur.*

By Georges Canetti. Éditions Médicales Flammarion, Paris. 225 fr. (paper). 338 pp.; ill. 1946.

The main body of this studiously compiled, inexpensively equipped, and somewhat diffusely organized monograph consists of a comprehensive review of controversial theories and inconclusive data on allergic phenomena in clinical tuberculosis. In this part of the book, the author's approach is generally on the conservative side, impartial, and always free of speculative assertion. In the concluding section, the author discusses his own views on the immunobiological and preventive aspects of the disease. Particular emphasis is placed on the inseparable interrelationship of allergic oversensitivity and immunity to reinfection. However, neither allergic nor immunological mechanisms are believed to play an essential part in the development of reinfection tuberculosis, although the available information about the responses of allergic and non-allergic persons to controlled gradations of exposure is considered inadequate. The most important causative elements are seen in the massiveness of exposure and in extreme deficiencies in the degree of natural resistance. The significance of genetically determined variations in natural resistance to tuberculosis is stressed, irrespective of a certain vagueness in defining the basic concept of natural resistance.

FRANZ J. KALLMANN

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MYCOSES AND PRACTICAL MYCOLOGY. *A Handbook for Students and Practitioners.*

By N. Gohar; with a foreword by Sir Philip Manson-Bahr. The Williams & Wilkins Co., Baltimore. $6.00. xii + 234 pp. + 4 plates; text ill. 1948.

Gohar's *Mycoses and Practical Mycology* is a new and useful addition to the growing list of handbooks on a subject of increasing importance to medicine. It presents a thoughtful discussion of theoretical as well as practical aspects of medical mycology. The roles of soil and decaying vegetation as reservoirs of fungi which may be normally saprophytes but can, under suitable circumstances, become pathogens is briefly but clearly stated.

Nearly half the book is devoted to epidermophytosis and other abnormalities of the skin or hair, in a few of which a fungous etiology is doubtful. The clinical aspects of various types of dermatophytosis, evolution of the lesion, appearance of the fungus, and treatment are fully discussed. A clinical classification of material is followed for the most part, although, as the author points out, there is some overlapping of mycological and anatomical groupings. The discussion of each mycosis is based upon definition, history, symptoms, diagnosis, and treatment. The author may not have intended this small volume as a reference book, but its usefulness would have been increased if citations to some of the important literature had been given.

It is regrettable that a book which will be accepted as authoritative is marred by a number of errors. After defining the blastomycoses as diseases due to infection with true yeasts, the author follows Dodge in classifying *Coccidioides immitis* as an ascomycete and discusses coccidioidomycosis as a blastomycosis. It is generally recognized, on the contrary, that *Coccidioides* is a phycomycete. Similarly the term ascus is misused in connection with *Histoplasma*, *Zymonema* (*Blastomyces*) and *Paracoccidioides* (which is erroneously related to *Coccidioides* rather than to *Zymonema*). The author apparently overlooked the prevalent benign type of coccidioidomycosis, i.e., "Valley fever," in stating that spontaneous cure is exceptional. "Torula meningitis" (cryptococcosis) and "Busse-Buschke's blastomycosis" are discussed as different diseases with different etiologies, although they are generally accepted as manifestations of one disease and have the same etiology. Similarly, *Monosporium apiospermum* and *Allescheria boydii* are presented as 2 different fungi although they are known to be growth forms of a single fungus. Numerous other departures from modern and accepted terminology and synonymy, particularly among the dermatophytes, might be cited. The history of actinomycosis is well told, but an old error is perpetuated by erroneously labeling as *Actinomyces bovis* a culture of an aerobic *Streptomyces*. Regardless of whether *Actinomyces bovis* or *A. israel* is accepted as the valid name for the etiologic agent of human actinomycosis, the name *A. bovis* cannot be used properly for an aerobic *Streptomyces*. It is stated that histoplasmosis (which actually is widely distributed over the world) is found only in the United States and Central America, although 2 pages later a case from Java is mentioned. Although their generally accepted nonmycotic etiologies are mentioned, 10 pages are devoted to a discussion of sprue and 5 pages to pinta. The last chapter presents a useful summary of fungicides, prescriptions, culture media, and poisonous fungi.

C. W. Emmons

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Science Versus Cancer. *Sigma Introduction to Science 2.*

By I. Berenblum. Sigma Books, London. 6s. 116 pp. + 8 plates. 1946.

Fowler in the *Concise Oxford Dictionary* defines *beautiful* as "morally or intellectually impressive, charming or satisfactory." This reviewer feels Berenblum's *Science Versus Cancer* is best described as beautiful. In 9 polished chapters: (The Nature of the Disease, its Frequency, the Influence of Heredity, the Influence of Environment, Diagnosis, Treatment, Cancer Research [2 chapters], and Retrospect and Prospect) the author presents the cancer problem in a manner which reveals him as a teacher, researcher, and a sensitive and understanding man. Written in non-technical terms for the layman, it is a model for the scientist who wishes to present to the curious citizen a view of this special field of interest. It can well serve the young practitioner as a guide in discussing the cancer problem with patient or family. Medical students could profit much by spending this hour with Berenblum. No biologist could fail to profit from reading *Science Versus Cancer*. The book has a glossary of terms and is adequately indexed.

M. C. Shelesnyak

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Atomic Medicine.

Edited by Charles F. Behrens. Thomas Nelson & Sons, New York, Edinburgh, and Toronto. $7.50. xiv + 416 pp.; ill. 1949.

The problem of presenting the field of nuclear physics to the student of medicine is a difficult one because of its extent, its numerous disconnected applications, and the inadequate training in basic sciences which is such a serious and outstanding defect in our medical education today. The discrepancy between present training given medical personnel and the scientific preparation required for proper application of the field of nuclear physics to medicine is an excellent illustration of this important failure of our medical schools. It is not clear whether this is adequately appreciated in the medical profession. From this it follows that a book on *Atomic Medicine* has a difficult goal to attain from the outset. It is obviously not possible within the confines of one book to provide an adequate education in atomic medicine for the medical man. By trying to cover the entire field Behrens' book fails to accomplish this aim in almost every phase of atomic medicine which it takes up. However, for those who wish a general survey of the whole subject it does give an easily read account of large portions of the field. This is provided in a generally uncritical fashion, without benefit of many data or extensive evidence. The material is presented by 20 contributors who give a discontinuous account containing many long repetitions. For an introduction to the field the book may be useful, although it is rather long for this purpose. At $7.50 it is overpriced, in my opinion.

Frederick W. Barnes, Jr.

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Malaria im Kindesalter. *Bibliotheca Paediatrica, Supplementa zu Annales Paediatrici, Fasc. 47.*

By Albert Eckstein. S. Karger, Basel (Schweiz) and New York. S. fr. 14.00 (paper). viii + 119 pp.; ill. 1946.

This strictly clinical monograph reflects the views of a prominent European clinician following a score of years of close contact with malaria in Turkey, where the disease has been common for centuries. The monograph has a somewhat wordy but methodical table of contents, and is divided into 4 large sections: an Introduction, a section on Prophylaxis, an extensive discussion of Clinical Diagnosis, Symptomatology and Pathology, and finally, a special section on the Care and Treatment of Childhood Malaria. The author feels that because of the frequent deviation of clinical malaria in children from the classical picture of adult malaria described in textbooks, the use of the term "childhood malaria" is justifiable. The Introduction is largely a discussion of the author's experience with malaria in pediatric clinics in Germany and especially in Turkey, and to an explanation of his reasons for writing the monograph. The author reports a mortality rate of 40% among malaria cases in children, 8.8% of which were in nursing babies, 18.6% among infants, and 12.4% in older children, for the years 1931–34.

The section on Prophylaxis considers prevention through anti-malarial campaigns, including mosquito eradication and suppressive medication as well as the elimination of clinical malaria after it has developed. The relative usefulness of the several available malariacidal drugs when applied to childhood infections is discussed.

In the discussion of clinical and laboratory diagnosis, proper emphasis is given to the need for adequate thick-film examination of blood, an especially important procedure because in children the symptomatology may and often does present manifestations of protean nature. This is especially true of the febrile curve, a notoriously poor diagnostic criterion for this age group.

The author describes a series of 14 cases, out of some 200,000 observed, in which what he felt was true congenital infection was demonstrable—an infection of the fetus having resulted from transplacental contact following injury to the placenta during extreme malarial paroxysms. The real number of such occurrences is, the author believes, actually much greater than has been supposed. Thus, a prophylactic program during pregnancy is highly indicated, for in addition to congenital infection, the danger of abortion is an ever-present threat to the health of mother and child. To combat this, Eckstein prescribes the use of atabrine or other essentially non-toxic antimalarials.

Clinical malaria of childhood is discussed under 3 sub-headings: nursing infants, young children, and older children. The first of these presents an especially atypical symptomatology. The paroxysms frequently do not include chills and fever, the rigors usually seen being replaced by "febrile cramps." If fever is seen at all, it is usually not very high. Although this suggests a low reaction of the infant to the toxic by-products of the parasitemia, appearance of splenomegaly is very common. Another frequent characteristic of this age group is dyspepsia and enteritis.

A frequent complication of malaria in young children is dystrophy. This closely resembles nutritional deficiency dystrophy of similar age groups. Eckstein says that among such cases, fever and splenomegaly may be slight or entirely absent, and the growth rate is so depressed that dwarfism is common in chronic cases. The connection of these symptoms to malaria is shown in the miraculous response following specific therapy.

Also included is a comprehensive consideration of the occurrence of liver cirrhosis and kidney damage among cases of childhood malaria. No connection was seen in the size of the spleen and the liver. In some cases, cirrhosis occurred in the complete absence of splenomegaly and vice versa. Malariacidal compounds, in the author's experience, had little or no effect in reducing the size of enlarged livers. Nephrosis seemed to be a frequent sequel of quartan malaria among children, but nephritis showed no connection whatever to any type, the former responding to antimalarial drugs, the latter not being affected. Carbohydrate metabolism was frequently upset in that blood and CSF sugar were found often elevated in severe cases.

Almost one-fourth of the monograph is devoted to the effect of malaria on the central nervous system of children. The various complications are classified into: (A) Prodromal Signs of the Coma Stage; (B) The Malarial Coma, with 8 subtypes which the author recognizes; and finally (C) The Sub-Acute Types of CNS Involvement, including 7 clinical subtypes. All of these forms of malaria are exhaustively discussed. Some of the material is repetitive and verbose.

The treatment of malaria in childhood is similar to that in the adult except for the difficulty in obtaining the cooperation of the child in taking distasteful drugs, so the author suggests the use of parenteral therapeusis wherever possible. A simple treatment regimen is outlined for both atabrine and quinine. The suggested use of plasmochin should perhaps have been accompanied with caution concerning its toxicity.

Although this monograph might have well profited from condensation, the information given is worthwhile and offers valuable pointers to the pediatrician.

ALAN C. PIPKIN

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PRINCIPLES OF INSECT PATHOLOGY. *First Edition. By Edward A. Steinhaus. McGraw-Hill Book Co., New York, Toronto, and London.* $8.00. xii + 757 pp. 1949.

Scarcely 10 years have elapsed since the study of insect physiology made its debut as a discrete discipline. It was heralded by the appearance of Wigglesworth's *Principles.* During the intervening period this offspring of entomology and physiology has waxed strong. Nonetheless, it is apparent that lacunae in our knowledge of the physiology of the normal insect far exceed the known framework. It might seem at first glance, therefore, that a book devoted to the abnormal physiology of insects, the functional, chemical, and structural alterations resulting from disease or injury, is premature. Yet a perusal of Steinhaus' signal work reveals that this is not the case. The field of insect pathology has heretofore occupied a relatively obscure position, largely because of its diffuseness; yet it is a field of endeavor which has claimed the attention of eminent scientists, among them Pasteur, for over 100 years. This volume introducing the science of insect pathology does yeoman service in concentrating an impressive volume of scattered and seemingly unrelated facts. The skill with which the material has been organized to produce a coherent treatise is commendable.

Although intended primarily as a textbook, this book fills the need for a reference work, too. It is composed of 14 chapters and has extensive author and subject indices. After an introductory chapter in which definitions are set forth and the historical background and techniques of insect pathology are discussed, the subject matter is divided as follows: mechanical, physical, and chemical injuries; diseases of nutrition and metabolism; extracellular microbiota of healthy insects; intracellular microbiota; infection and epizootiology; resistance and immunity; symptoms and pathologies; bacterial infections; fungus infections; virus infections; protozoan infections, nematode infections, applied insect pathology, and biological control. The book is very well written and profusely illustrated.

Extensive references at the ends of chapters are especially helpful. This book should fulfil not only its purpose as an introduction to the study of insect pathology and a reference work but should also act as an incentive to potential workers in the field.

V. G. Dethier

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Mosquitoes and their Relation to Disease. *Their Life-History, Habits and Control. Fifth Edition. Brit. Mus. (Nat. Hist.)—Econ. Ser. No. 4.*
Printed by order of the Trustees of the British Museum by William Clowes and Sons, London and Beccles. 6d. 17 pp. 1949.

PSYCHOLOGY AND ANIMAL BEHAVIOR

Army-Ant Life and Behavior under Dry-Season Conditions. *3. The Course of Reproduction and Colony Behavior. Bull. Amer. Mus. Nat. Hist., Vol. 94: Art. 1.*
By T. C. Schneirla. $1.00 (paper). Pp. 1–82 + 2 plates; text ill. 1949.

On the Relationship of Social Behavior to Pigmentation in Tropical Shore Fishes. *Bull. Amer. Mus. Nat. Hist., Vol. 94: Art. 2.*
By C. M. Breder, Jr. 50 cents (paper). Pp. 83–106 + 8 plates; text ill. 1949.

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General Psychology. *Second Edition.*
By W. J. H. Sprott. Longmans, Green & Co., London, New York, and Toronto. 14s. x + 467 pp. 1947.

An inclusive exposition of basic psychological phenomena and processes, as well as of various frames of reference in psychology, is offered in this revised edition. The usual gallery of topics in general psychology is presented, along with such chapters, strange to American students, as those on Other People (separate from Social Environment) and The Field of Consciousness (separate from The Perceptual Field), as well as the concluding one, The Relation Between Body and Mind.

The work as a whole is nonexperimental in tone, and expository in the manner of a text in metaphysics or epistemology. It is freighted with the concepts and metaphysical conjectures that characterize the introspectionist, philosophical strain of much traditional British academic psychology. Interestingly enough, however, such emphases in the areas of perception, consciousness, and the thought processes seem to make portions of this text more relevant for an appreciation of the latest developments in perceptual theory and projective psychology in this country than most American textbooks in general psychology. At the same time, however, the reader is left with an impression that psychology has but lately emerged from philosophy, and that the adequacy of its hypotheses can be tested by mental operations based on the private experience of the "psychologist." This impression is not weakened by the author's inclusion of the speculations and fantasies of Jung, Melanie Klein, and Gerald Heard in his exposition.

Unlike American textbooks, the topic of psychical research is defined and discussed in the most speculative manner, with only casual reference to experiments. In this connection it is remarked that "psychologists should not shrink from penetrating the obscurities of psychic research; there is sufficient evidence to invite investigation, and the position of an ostrich with its head buried in the sand is neither dignified or helpful" (p. 288). We are not, however, told what "sufficient evidence" is, nor on the other hand why "dignity" and "helpfulness" are crucial in the conduct of scientists. A versatile receptivity to a variety of theoretical viewpoints and possible hypotheses is indispensable for the growth of understanding, prediction, and control. But if intellectual appreciation and philosophic appraisal luxuriate at the expense of empirical verification, an exposition of psychology can hardly command the respect that the labors of its researchers and practitioners today so justly deserve.

Erling Eng

◆

General Psychology. *Principles and Practice.*
By John Edward Bentley. J. B. Lippincott Co., Philadelphia, London, and Montreal. $3.50. xviii + 389 pp. + 5 plates; text ill. 1947.

This book is the precipitate of experience in teaching introductory psychology to nurses. The material is divided into 5 sections: The Organic Basis of Human Psychology, Sense Activity and Sense Experience, Learning, Personality Adjustment, and Applications of Psychology to Nursing. Basically, the book is little more than an outline of the various topics in general psychology. Sensory, motor, and neural mechanisms are presented in some detail, in accordance with the author's belief in the importance of the organic basis of all behavior. In addition, thumb-nail characterizations of the various "psychologies" are included, as well as a trivial, misleading section on Clinical Psychology. On the whole this is an unfortunate book, both for the reputation of psychology, and for the understanding of students. Typical passages like the following disclose an unconscionably superficial understanding of personality structure:

> "There is always the danger of the normal man or woman faltering, failing, falling from the path of normal behavior, for the line of demarcation between normal

and morbid behavior is very thin. At any moment the normal man may fail and become a part of the army of misfits, the mentally sick, and flounder in his normal tasks, swelling the growing tide of human failures. This danger is well illustrated by the fact that the annual increase of mental patients in our hospitals has risen to four and one-half per cent and the rate is rising" (p. 267).

It is difficult to recommend such a misleading and poorly-written book for any class in psychology.

ERLING ENG

◆

AIDS TO PSYCHOLOGY. *Third Edition.*
By John H. Ewen. Baillière, Tindall and Cox, London. $1.75. viii + 192 pp. 1948.

This small book has been written as a study aid for British students preparing for a "Diploma in Psychological Medicine." It attempts to provide a comprehensive but concise review of the concepts, principles, laws, and classificatory schemes contained in the academic psychology usually encountered by such students. Some idea of the frame of reference of this psychology may be gained from the following selection of chapter headings: Body and Mind; Cognition, Conation, Affection; Instinct; Imitation; Belief; Sentiment; Complex, Dissociation, Types of Thinking; Illusion, Hallucination. Most generously reviewed and expanded are the concepts and classifications of McDougall (all 14 of his "major instincts" are discussed), accompanied by passing references to such worthies of an earlier day as Stout, Ward, Ladd, and James.

Characteristic of the era of psychology from which the views summarized in this book have descended are statements like the following:

> "Mental dispositions are unconscious factors connected with consciousness" (p. 38).
>
> "The food-seeking instinct is exhibited in various forms, and is variously specialized. Its emotion is gusto. The impulse to wander in search of food differentiates animals from plants" (p. 71).
>
> "Emotion is a mode or quality of experience. The emotions are varieties of emotional experience. The emotional qualities, when functionally considered, are subjective or significant of the nature of the subject" (p. 124).

Outside the special audience for which it has been tailored this book is likely to occasion scant interest because of the outworn taxonomic approach to "mental phenomena" that it so largely exemplifies.

ERLING ENG

◆

PROBLEMS OF HUMAN ADJUSTMENT.
By Lynde C. Steckle. Harper & Bros., New York. $3.00. xii + 351 pp. 1949.

This book is designed as a "text for courses in mental hygiene, personal adjustment, and personality development." Its central theme is that man is primarily an emotional being, subject to the atavistic controls of his formerly necessary, but now relatively useless, physiological preparatory adjustments. These responses are effective through the "old brain" and, when not fully recognized and controlled by the "new brain" of modern man, lead to maladjustment. While this anatomical and evolutionary pattern is inevitable and leads the author to be rather pessimistic in his outlook for the species at some places in the book, his general view is that understanding and the exercise of intelligence will make successful living possible. This faith in the possibility of intellectual control over the emotional patterns of response is carried through consistently. In discussing courtship, for example, Steckle says: "If your boy or girl friend is constantly on the watch for signs that your affection is wanting, if he or she seems to feel that you are not to be trusted out of sight, break it off." The assumption that this is easy appears unrealistic. The consistent faith prevails through a discussion of religion that rather cavalierly disposes of the whole of that problem as myth and superstition. It resolves into an ethical philosophy very like that of the Golden Rule.

The concept that intelligence or "new brain" offers the complete solution to life's problems marks this book as rather less than modern in its psychotherapeutic content. It pays little heed to the usefulness of the attitudinal changes that appear in the interview, for example, though this technique is dealt with briefly in the last chapter. Very little is said about the powerful factors of rapport and transference. The book is largely mechanical and not very human.

PAUL V. LEMKAU

◆

MORE ABOUT PSYCHIATRY.
By Carl Binger. The University of Chicago Press, Chicago. $4.00. xiii + 201 pp. 1949.

This little book is a compilation of several articles that Binger has written for various journals, medical and lay. It touches on a variety of subjects: psychosomatic disorders, mental health, anxiety, what can be learned from medical history, choosing a mate, psychoanalysis, and so on. The author's style is easy and will ingratiate itself with the lay reader. Furthermore, the material he talks about is factual, presented so that the reader will get an authentic account. Some of these chapters have been read widely already, since they appeared in national journals, and it is rather pleasant now to have this group of informal essays for general distribution in book form. There is a considerable bibliography for each chapter.

WENDELL MUNCIE

Guiding Human Misfits. *A Practical Application of Individual Psychology. New and Revised Edition.*

By Alexandra Adler. Philosophical Library, New York. $2.75. 114 pp. 1948.

Alexandra Adler is the daughter of Alfred Adler, a Viennese psychologist noted for having split with Sigmund Freud in postulating inferiority feelings as the fundamental conflict in personality disorders. She has written this short book for the lay public, apparently to present her father's thesis in popular form. In so doing she has set aside considerations of more involved psychodynamics and has made the field of psychiatry appear phenomenally simple.

Helen Arthur

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Guidance Policy and Practice.

By Robert Hendry Mathewson. Harper & Bros., New York. $3.00. xiv + 294 pp.; ill. 1949.

The presentation in this volume differs from that of the other recent publications in that its primary aim is to formulate a framework which will fit all guidance activities into the contemporary pattern of our social and industrial structures. Since the author wishes to present the theoretical implications of guidance, he writes only in terms of the philosophical, sociological, and educational connotations of the guidance movement rather than in strictly scientific and technical terms. He would like to bring some semblance of law and order into the thinking of the educators and administrators who are responsible for organizing and promoting programs in a field which in its brief history has had something in common with Topsy's growth.

An educator attempting to fit the guidance field into such a sociological perspective faces the dilemma of the somewhat dichotomous nature of guidance. He may take as his primary point of departure the special attributes and aptitudes of the individual, and the world into which he must fit as a secondary concern; or he may start with the needs of the social structure, and attempt to have the guidance process serve social ends. Mathewson has tried to knit the two phases together and to show that in actuality they are not divorced. "The kind of society," he states, "which provides maximum freedom and opportunity for individual development can be neither individualistic anarchy nor a tyrannical despotism. The solution sought is a constantly adjusting dynamic reciprocation of individual and social interest. Thus the foremost social imperative in a democracy is to provide the type of education on the one hand which will make its citizens wise choosers and purposers, and the type of society on the other in which such choosers and purposers can harmoniously develop." Because perspective as to the place of guidance in the current scheme of our civilization is the keynote of the book, a psychological specialist may well look in vain for any technical discussion here of the scientific methods and tools involved in the practice of his profession. The book appears to be written essentially by an educator *for educators*, and a highly technical discussion of the guidance process is not the intent of the book.

Marion R. Bartlett

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The Psychobiological Program of the War Shipping Administration. *Applied Psychology Monographs, Number 12.*

Edited by Goerge G. Killinger, with a foreword by Captain Edward Macauley, and an introductory chapter by Justin K. Fuller. Published for the American Psychological Association by Stanford University Press, Stanford University; Geoffrey Cumberlege, Oxford University Press, London. $4.00 (cloth); $3.00 (paper). 351 pp. + 19 plates; text ill. 1947.

This monograph describes the psychobiological phases of the responsibilities of the War Shipping Administration during World War II. These responsibilities included an extensive program of selection, training, and maintenance of the large number of personnel operating the greater proportion of merchant vessels during the conflict. It is fortunate that this monograph has been published, since few people even in the field of psychology are aware that this program existed. It has not been as widely known as the similar work in the military services. The program was operated by the USPHS in conjunction with their legal responsibility of caring for the health of the Merchant Marine.

The origin of the activities is presented, along with a general discussion of the purpose and function of the psychobiological aspects of the program. These involved procurement and selection of personnel, with most emphasis placed on the elimination of emotionally unstable individuals. Following selection, cadets were placed in training schools either of an elementary training nature or special schools for upgrading for specific skills or for officer material. One of the large aspects of the work was rehabilitation of mental casualties following the strain of severe operating conditions or battle action. This included rest programs and, where necessary, active therapeutic treatment.

For purposes of selection a Group Personality Inventory and Personal Data Sheet were developed which served as the core of all screening. These are primarily psychiatric inventories employed to eliminate the placement of potential psychotic and psychoneurotic individuals in the crews of vessels subject to war conditions. The authors contend that after several revisions of the inventory they were able to establish a critical score that screened out 66 per cent of the neuropsychiatric subjects while only eliminating 6 per cent of the normal subjects.

Section D of the report, in 6 chapters, presents a sampling of the characteristics of wartime merchant seamen, such as background, color training problems, literacy, etc. The area of Mental Hygiene activities includes educational methods, morale building procedures, training for leadership, and the psychobiology of the purser-pharmacist's mate who was expected to help maintain the psychological health of the men at sea. The evaluation of the entire program is based on a complete record system and follow-up studies of the men who were selected, trained, and assigned to duty by the service. The report presents a thorough use of neuropsychiatric techniques applied to a specialized group of individuals under stress conditions. With careful variation, many of the techniques could be employed with other specialized groups of men needed in large number for such restricted duties.

R. Y. Walker

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Modern Sex Life. *With Case Histories. Second Edition.*

By Edwin W. Hirsch. Permabooks, New York. 35 cents (paper). xvi + 236 pp. 1949.

This little book is a regrettable addition to the literature on sexuality destined for popular consumption. In his chapter on the Kinsey Report, after glorifying it as having "awakened great national interest" and . . . being "great and monumental," the author says that this "would not have been possible without the pioneer work of Freud. He was the brilliant researcher, proved many of the illnesses of the mind were caused by not living a wholesome sex life." With this doubtful tribute to Freud, he goes on to show that he has only the faintest conception of the psychology of sexuality. An example of a pernicious doctrine to be spread wholesale among laymen is the assertion that during intercourse, if the female partner tends to be frigid, it is the male's obligation to masturbate her by massage at the clitoris. True, the advice is not couched in such bald terms but that is exactly what it amounts to. This will show the extent of the author's ignorance concerning sexuality, and the untold harm that may result from the propagation of such doctrines. There ought to be some way to prevent the wide distribution of such books.

Wendell Muncie

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The Psychology of Sex. *Pelican Books A194.*

By Oswald Schwarz. Penguin Books, Harmondsworth, Middlesex. 1s. 6d. (paper). 296 pp. 1949.

This is an excellent small pocket-book on the sexual function as an item in overall personality function, and it is to the author's credit that at no point does he deviate from sexuality in this light. This book can be thoroughly recommended. It is full of wisdom, both for medical persons and the laity, and it is to be as much recommended as the book by Hirsch (reviewed above) is to be condemned. Throughout the book there is an implicit or outright plea for the inclusion of the sexual life under the principle of morality, and while the author's view of morality may not suit certain rigid conceptions of the subject, it will find wide acceptance in medical circles.

Wendell Muncie

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Psychosexual Development in Health and Disease. *The Proceedings of the Thirty-Eighth Annual Meeting of the American Psychopathological Association, Held in New York City, June, 1948.*

Edited by Paul H. Hoch and Joseph Zubin. Grune & Stratton, New York. $4.50. x + 283 pp. 1949.

This volume probably contains more meat, more sense, and sheds more scientific enlightenment on the complex problems of psychosexuality than the entire flood of reports, commentaries, case studies, and discussions that appears to have been the mainstay of publishers and printers for the last half-decade. It can be recommended to the readers of this *Quarterly* without reservation and with the single qualification that it is not nearly long enough—a qualification that can hardly be made for most books today.

The volume is a multi-disciplined survey in which the field of sexuality is exposed to the respective attentions of taxonomists, biologists, anthropologists, psychologists, psychiatrists, psychoanalysts, and sociologists. What emerges is a comprehensive and panoramic perspective of the field, literally a topography which, while it exposes more than anything the arid wastes of our knowledge, occasionally reveals the gardens and orchards that have been well-tended. The first paper, in which the basic problem is stated, is by the authors of "The Report," Kinsey et al. While it is somewhat pompous and didactic in tone, it performs its introductory function. Gantt, and then Beach, next expound pertinent biological data. C. S. Ford then informs us of the parallelisms that obtain as to sex mores among 150 cultures apart from our own. At the end of this section, Kardiner objects that what has thus far been presented is dangerously misleading, and he deplores work which compares human sex behavior with animal behavior or draws unwarranted and untenable inferences from practices in primitive societies where the social context in which such behavior takes place is so different from ours.

The anthropologists, Henry, Hallowell, and Mead, command attention to their data in the second section. In the third, R. L. Frank opens the psychoanalytical discussion with an excellent summary of Childhood Sexuality. Rado follows with a "rediscovery of the obvious" and interestingly develops his adaptational view of sexual behavior, which includes a reexamination of the libido theory. Unfortunately, this article suffers from too much condensation, and one wishes Rado had had more time to develop his thought. Bychowski is competent in an article dealing with psychoanalytic experience in the light of the Iowa researchers' findings. In an address, Knight correctly blasts the "strong-arm" methods of therapy with patients who suffer from psychosexual disorders.

In the last section the sociologists, Burgess, Frazier, and Murdock, have their say. Murdock's paper surveys 250 societies. He finds intrafamilial incest taboos universal, premarital license granted among three-quarters of human society, and strikingly states that "our own sexual code is even more of an ethnological curiosity than is cannibalism or the couvade." Discussing this article, Kingsley Davis rejects the interpretations Murdock places on such data.

All considered, the American Psychopathological Association is to be congratulated for having assembled this material. I would, however, rebuke the publishers for not providing the volume with a more provocative title to insure a wider distribution. A book like this could be a much-needed antidote to the trash circulating today under the guise of science.

ROBERT LINDNER

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HUMAN BIOLOGY

DAS RELIGIOSE WELTBILD EINER FRÜHEN KULTUR.

By Ad. E. Jensen. August Schroder, Stuttgart. DM 12.50. xii + 199 pp.; ill. 1949.

This recent book of the well known Africanist, Director of the Frobenius Institute in Frankfurt, is rather representative of the orientation of the majority of present day German ethnologists. Their approach is historical, that is to say, they approach a primitive culture primarily in order to understand its place and role in the prehistory of mankind. Jensen agrees in principle that phases of this history can be isolated in the form of "culture areas" or "cultural cycles," but is highly skeptical as to the validity of those "cultural cycles" reconstructed in the past by Frobenius, Graebner, Ankerman, Father Schmidt, and others. After undertaking a criticism of Frobenius, he feels that these reconstructions have so far been based on statistical work with heterogeneous, mostly material elements (studied in museums), and have therefore been condemned to failure in view of the organismic quality of cultures. (This is the "gestalt" approach, entering German ethnology through Frobenius and Krause in the 1920's, U. S. anthropology through Benedict, Opler, and others, in the 1930's.) Jensen bases his reconstruction on mythology as being more likely to reflect central themes (patterns, configurations, the "Weltbild"—world view) of different cultures. He starts with the myth of the killing of the lunar goddess in West Ceram (Indonesia), discovered by himself, and marking the beginning of death *and* procreation among men and the cultivation of plants. Many ceremonials, especially puberty ceremonials, enact this myth. Jensen finds the same myth and ceremonials in such different tribes as the Marind-Anim, Kiwai-Papuans, Khond, Californian Indians, Uitoto, Pangwe, and Southern Rhodesians. He finds clear remnants of it in the Eleusinian mysteries, and other religious productions of high culture. These parallels that cannot be explained by psychology suggest the widespread existence of an early culture, introducing the domestication of plants and creating this particular myth. Jensen calls this "Kulturkreis" tentatively "lunar" and shows his relations to earlier studies of Frazer, and to the "malayonigritic" (or "equatorial," etc.) "Kulturkreis." This short summary can by no means do justice to the perspicacity, caution, and insight of Jensen's study. There is an English summary of 8 pages.

ERWIN H. ACKERKNECHT

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IBO VILLAGE AFFAIRS. *Chiefly with reference to the Village of Umueke Agbaja.*

By M. M. Green. Sidgwick and Jackson, London. 10s. 6d. xii + 262 pp. + 1 map. 1947.

In the midst of the kingdoms of West Africa, well known for their high degree of political organization, live nearly four million Ibo-speaking people, crowded together in Southeastern Nigeria to the extent of 300 to 1300 heads per square mile, in a state of complete political atomism. The fact is an unusual challenge to the social scientist, and an unusual headache to colonial administrators. Through prolonged studies in an Ibo village, Mrs. Green has tried to ascertain those elements of social cohesion that permit a normal functioning of Ibo society in such unusual circumstances. Even in the village, which is the only political unit, authority is dispersed among groups rather than centralized in any individual or body. Kinship, religion, and markets are integrating factors. Strict exogamy combined with polygamy tends in the case of the Ibo to establish bonds beyond the village and to mitigate intervillage fighting. Women's organizations, on a village basis as well as that of a common place of descent, play an important role. This most excellent monograph keeps up the high standards for which we envy the British school of cultural anthropology. It is equally attractive because of its new and interesting data and its lucid and intelligent presentation of them.

ERWIN H. ACKERKNECHT

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HORTUS GUARANENSIS. *Generalidades. Segunda Parte.*

By Julio S. Storni. Gabinete de Etnologia Biológica, Universidad Nacional de Tucumân, Tucumân, Argentina. (Paper). 136 pp. 1948.

This is the second of 2 volumes dealing not with plants but with the etymology of the language of the Guaraní. Among other things the first volume (1939) dealt with the toponyms, foods, institutions, etc., while the present one touches upon the physical organism, including its organs and functions, psychical faculties, diseases, etc. The main body of the work is an etymological account of Guaraní with an interpretation of each term including the Spanish equivalents. The author hopes that the study of this work, along with the several companion volumes in this series, may give some idea of the cultural state to which the Guaraní had risen at the time of the Spanish Conquest.

W. H. Hodge

BIOMETRY

The Science of Chance—*From Probability to Statistics.*

By Horace C. Levinson. Rinehart & Co., New York. $2.00. viii + 348 pp. 1950.

The science of statistics got its start from the questions which professional gamblers put to mathematicians three centuries ago. Levinson follows this historical route in his approach to statistics. The first 13 chapters of his book are concerned with statistical aspects of games of chance—poker, roulette, lotteries, craps, and bridge. The last 6 chapters deal with statistics proper and with their use in a variety of applications, principally business.

The Science of Chance is a revision of the author's earlier book, *Your Chance to Win.* It is not a text on statistics, but rather a book about statistics and the theory of probability. Reading this book will not make anyone a statistician, but it will certainly leave him with a clear notion about the fundamentals of statistics and statistical reasoning. Even if the reader has no interest in statistics as such, he is almost certain to be fascinated by the lucid discussion of luck, gambling, and games of chance. The author's treatment of the subject, incidentally, is almost entirely at the verbal level; formulae and numerical materials have been kept at a minimum.

A. Chapanis

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

Author's Guide *for Preparing Manuscript and Handling Proof.*

John Wiley & Sons, New York. $2.00. xv + 80 pp. 1950.

It can be said without fear of contradiction that practically all editors of scientific journals and all publishers will agree when it is stated that a book such as this should be in the library of those who write for publication and, furthermore, should be *regularly* consulted.

David B. Tyler

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Histologische Technik. *Einführung in die Technik der normalen und pathologischen Histologie für Anfänger. Einführung in die medizinische Laboratoriumstechnik in Einzeldarstellungen.*

By Thilde Gröbl. Verlag Wilhelm Maudrich, Wien. $5.40. viii + 201 pp. 1950.

This is the second volume of a 2-volume series edited by Thilde Gröbl and Maria Fischer-Gröbl. The first volume (by the latter author), not reviewed here, is concerned with clinical-chemical methods of medical laboratory technique. The second volume is the usual indispensable handbook for the student or hospital technician, containing introductory chapters on the microscope, microtome, handling of materials, fixation and clearing, followed by specific techniques of staining and preparation. The book does not aim to be encyclopedic, but it is representative and not all elementary. Many of the techniques are of recent origin or modification. Thus the Papanicolaou diagnostic technique for tumor cells is given, as well as a modification of it. Since the text is German, it is unlikely that it will be adopted for class use in this country, but it could be profitably employed as a reference book.

Earl H. Newcomer

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Practical Section Cutting and Staining.

By E. C. Clayden. Chemical Publishing Co., Brooklyn. $2.75. viii + 129 pp. + 3 plates; text ill. 1948.

The author states in the preface of this book that it "is written essentially for technicians with little or no experience in the various methods of preparing routine sections. . . . Covering the basic principles of histological technique, it is hoped that this book will be found valuable for those intending to sit the examinations of the Institute of Medical Laboratory Technology." The author, being Senior Technician in a London hospital, would seem to be well qualified for such a work, and his book testifies to his competence.

The book should find a wider use than that hoped for by the author. Teachers could well use it for a textbook, and practicing technicians will learn from it some new or modified techniques. However, possibly its greatest value for the latter lies in what the author refers to as tips. These are observations as to why a thing won't work, how to do it and why, things to cleave to or eschew, etc., those invaluable tidbits of information which often make the difference between a good or a bad preparation, or technician.

The style is terse, succinct, and authoritative, without being dogmatic or conveying the impression that this is the only way to do it. The book avoids the cook-book air of finality and orthodoxy, especially in the sections devoted to fixation and clearing, by discussing the advantages and disadvantages of the respective techniques. Nothing of microscopy, staining in general, nor theory are included, the bulk of the book consisting of specific techniques for specific purposes. There are some line drawings and a few nice photomicrographs.

EARL H. NEWCOMER

LABORATORY TECHNIQUE IN BIOLOGY AND MEDICINE. *Second Edition.*

By E. V. Cowdry. The Williams & Wilkins Co., Baltimore. $4.00. vi + 269 pp. 1948.

The first edition of this well prepared, comprehensive manual was published in 1943 under the title *Microscopic Technique in Biology and Medicine* (cf. *Q.R.B.*, 19: 158). The present edition retains the original form and style but has been expanded considerably to include new methods which have come into use as a result of recent advances in physical and microchemical procedures. Many of the standard techniques also have been revised. In its new form it continues to be one of the outstanding manuals of histological technique and should find even wider use than previously.

MARY E. RAWLES

CE QU'IL FAUT SAVOIR SUR LE MONDE MICROSCOPIQUE. *Méthodes de Récolte, d'Examen et de Préparation; Eléments de Microphotographie.*

By L. J. Laporte. Paul Lechevalier, Paris. 400 fr. (paper). 315 pp. + 24 plates; text ill. 1946.

This is a popular introduction to the varied uses of the microscope, intended for amateur microscopists. It is similar in general scope to the larger French works of Langeron and Séguy, but much less detailed. The text figures are of poor quality, but some of the plates of photomicrographs (diatoms, radiolarians, etc.) are excellent.

M. J. D. WHITE

LE MICROSCOPE: *Emploi et Applications. Volume II. Encyclopedie Pratique du Naturaliste. XXXIV.*

By E. Séguy. Paul Lechevalier, Paris. 2,000 fr. Pp. 321-1062 + 99 plates; text ill. 1949.

This is the second volume of a general work on microscopical technique, consisting of numbered paragraphs dealing with technical methods of the most diverse kinds. In the present volume there are 1182 such paragraphs devoted to methods for studying particular groups of animals, histology, coprology, botany, geology, metallurgy, photomicrography, microchemistry, etc. The arrangement of these sections does not seem to follow any orderly plan and the work as a whole is an uncritical compilation. Many of the sections are too brief to be of real use to a serious investigator, and a high proportion of the methods are somewhat archaic. The bibliography of 38 pages is perhaps the most useful feature of the book. Following the text is an "atlas" of 200 expensively produced plates, 12 of which are in color. Some of these are of microscopes (Zeiss, Bausch and Lomb, Cooke Troughton and Sims, and other makers); the remainder depict microscopic "objects" of the most varied kinds. The utility of these plates in a work of this nature is not obvious.

M. J. D. WHITE

OPTICS. *The Technique of Definition. A Focal Press Book.*

By Arthur Cox. Pitman Publishing Corp., New York. $5.75. xii + 412 pp.; ill. 1949.

Biologists have come to rely heavily on photographic methods for recording all manner of data, and know that the lenses involved in such work are the most expensive part of the equipment. So many factors are possible variables in lens design, and the interrelationships among these factors are so complex, that each lens is a compromise planned for definite types of use. The nature of these compromises, and the way in which they affect the manner of employing each lens for maximum definition, is the basic subject of this practical, straightforward book. As such it will be of immense value among scientists. The subtitle Technique of Definition indicates the direction in which Cox's treatment is aimed. He discusses at length the "ideal lens" and its difficulties, the chief lens types, their variants and applications—always with a helpful comment on possible interchangeabilities. Depth of acceptable focus is treated fully. Procedures in testing optical equipment are outlined in enough detail to enable any careful experimenter to learn how far he may expect his lens systems to go in a number of directions. Chapters on Aids to Better Performance and on Accessories add a number of precise physical techniques to the general run of attachments and gadgets on the market, and indicate the benefits to be derived from use of each. A number of excellent tables, an abundance of pertinent line drawings, a glossary, bibliography, and index extend further the reference value of this readable book.

LORUS J. & MARGERY J. MILNE